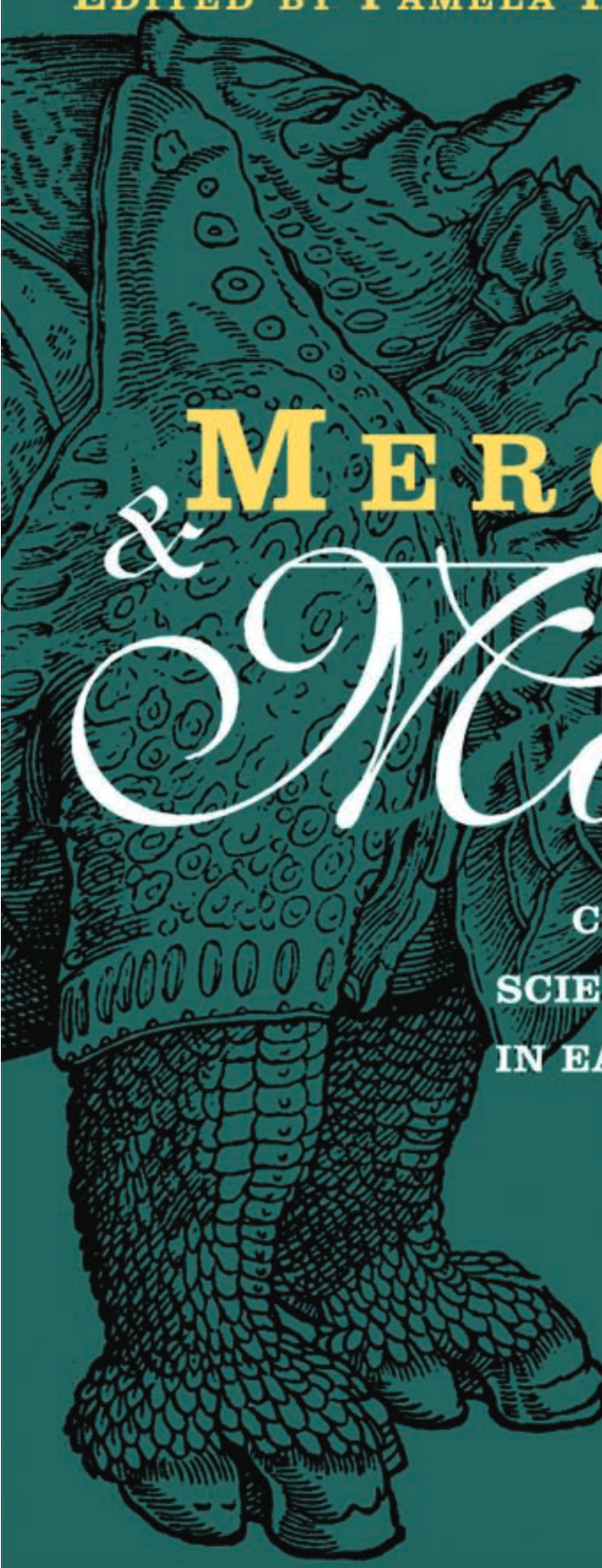
EDITED BY PAMELA H. SMITH & PAULA FINDLEN



MERCHANTS & *Marvels*

COMMERCE, SCIENCE, AND ART IN EARLY MODERN EUROPE

MERCHANTS & Mariels

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MERCHANTS & Marvels

Commerce, Science, and Art in Early Modern Europe

Edited by

Pamela H. Smith & Paula Findlen

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Contents

Acknowledgments ix

Introduction 1

Commerce and the Representation of Nature in Art and Science

PAMELA H. SMITH AND PAULA FINDLEN

Part 1 STRUGGLING WITH REALITY

Visualizing Nature and Producing Knowledge

1 Splendor in the Grass 29

The Powers of Nature and Art in the Age of Dürer

LARRY SILVER AND PAMELA H. SMITH

2 Objects of Art/Objects of Nature 63

Visual Representation and the Investigation of Nature

PAMELA O. LONG

3 Mirroring the World 83

Sea Charts, Navigation, and Territorial Claims in Sixteenth-Century Spain

ALISON SANDMAN

4 From Blowfish to Flower Still Life Paintings 109

Classification and Its Images, circa 1600

CLAUDIA SWAN

5 "Strange" Ideas and "English" Knowledge 137

Natural Science Exchange in Elizabethan London

DEBORAH E. HARKNESS

Part 2 NETWORKS OF KNOWLEDGE
Commerce and the Representation of Nature

6 Local Herbs, Global Medicines 163
Commerce, Knowledge, and Commodities in Spanish America
ANTONIO BARRERA

7 Merchants and Marvels 182
Hans Jacob Fugger and the Origins of the Wunderkammer
MARK A. MEADOW

8 Practical Alchemy and Commercial Exchange in the Holy Roman Empire 201
TARA E. NUMMEDAL

9 Time's Bodies 223
Crafting the Preparation and Preservation of Naturalia
HAROLD J. COOK

10 Cartography, Entrepreneurialism, and Power in the Reign of Louis XIV 248
The Case of the Canal du Midi
CHANDRA MUKERJI

11 'Cornelius Meijer inventor et fecit' 277
On the Representation of Science in Late Seventeenth-Century Rome
KLAAS VAN BERKEL

Part 3 CONSUMPTION, ART, AND SCIENCE

12 Inventing Nature 297
Commerce, Art, and Science in the Early Modern Cabinet of Curiosities
PAULA FINDLEN

13 Nature as Art 324
The Case of the Tulip
ANNE GOLDGAR

14 Inventing Exoticism 347
The Project of Dutch Geography and the Marketing of the World, circa 1700
BENJAMIN SCHMIDT

15 Shopping for Instruments in Paris and London 370
JAMES A. BENNETT

EPILOGUES

A World of Wonders, A World of One 399
LISSA ROBERTS

Questions of Representation 412
THOMAS DACOSTA KAUFMANN

Contributors 423

Index 427

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By all reports, edited volumes are the source of many tribulations. Our experience has been otherwise; we feel richly rewarded by the conversations this volume has spurred and by the opportunity the contributors have afforded us to collect their thoughts into this volume. Our thanks to all of them for helping us to bring merchants and marvels together.

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Introduction

Commerce and the Representation of Nature in Art and Science

PAMELA H. SMITH AND PAULA FINDLEN

On May 20, 1515, an Indian rhinoceros *(Rhinoceros unicornis)* arrived in Lisbon aboard the *Nostra Señora de Ajuda,* a Portuguese trading ship from India. It was the first rhinoceros to reach Europe alive since the third century. A diplomatic gift to Alfonso d'Albuquerque, governor of Portuguese India (1509–15) by Sultan Muzafar II (1511–26), ruler of Cambaia, or Gujarat, the animal was passed by Albuquerque to his king, Don Manuel I (1495–1521) in 1515. Later in the same year, Manuel sent the rhino as a diplomatic gift to the Medici Pope Leo X (1513–21) via Marseilles, where it was seen by King Francis I of France. Dressed with a gilt-iron chain and a green velvet collar decorated with gilt roses and carnations, the rhinoceros drowned when its ship sank off the coast of Italy. It followed in the wake of an elephant named Hanno that actually made it all the way to the papal city in 1514.[1]

The rhinoceros, circulating in Europe as part of a gift economy—not yet commodified—was brought to Europe within the framework of global commerce. Large gifts of nature were tangible signs of European overseas expansion, through trade or conquest, into regions where the "marvels of the East" could be found. If the rhinoceros itself was never fully commodified, its portrayal in a drawing of 1515 sent to an unknown acquaintance by Albrecht Dürer did circulate as a commodity of sorts (fig. Intro 1). Dürer had transferred the visual and verbal description of his drawing to a woodcut that served as the model for numerous reproductions in the following centuries and was disseminated very widely. Increasingly the rhinoceros became the artist's image of it. Dürer participated in shaping the verisimilitude of his rhinoceros by describing it enthusiastically although he never saw it himself:[2]

> In the year 15[1]3 [this should read 1515] on 1 May was brought to our king of Portugal in Lisbon such a living animal from India called a

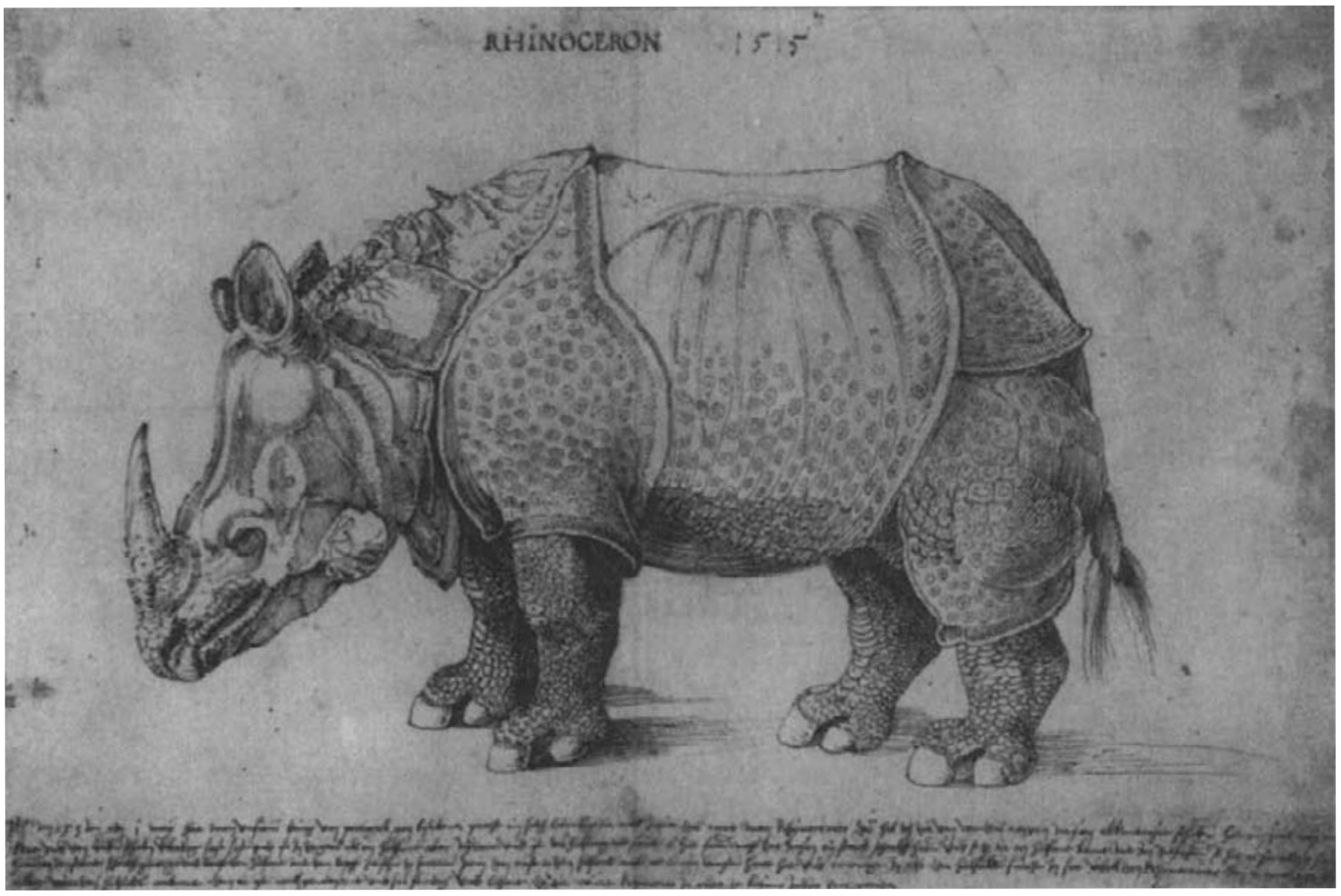

Figure Intro.1 Albrecht Dürer, *Rhinoceros*, 1515. Copyright © The British Museum.

> Rhinocerate. Because it is such a marvel I considered that I must send this representation. It has the colour of a toad and is covered all over with thick scales, and in size is as large as an elephant, but lower, and is the deadly enemy of the elephant. It has on the front of the nose a strong sharp horn: and when this animal comes near the elephant to fight it always first whets its horn on the stones and runs at the elephant with its head between its forelegs. Then it rips the elephant where its skin is thinnest and then gores it. The elephant is greatly afraid of the Rhinocerate; for he always gores it whenever he meets an elephant. For he is well armed, very lively and alert. The animal is called rhinocero in Greek and Latin but in Indian, gomda.[3]

Dürer used the term *abkunterfet* to describe his portrayal of the animal, a term that often implied "copied from life,"[4] and thus left open to his correspondent the question of whether he had portrayed this particular rhinoceros from the living model. In reality, he probably copied his description from a report and drawing (now lost) sent to Nuremberg by a member of the German community in Lisbon, yet Dürer's image of this wonder, which went on to have an extraordinary life in copies, was probably taken by most viewers to be an accurate rendering of a strange and exotic beast.[5] It had the descriptive, realist "mark of truth" that became signature in the work of Dürer and his followers, and also appeared in works of scientific illustration

at about the same time.[6] By the mid-sixteenth century naturalists would commonly refer to their illustrations of nature as being done *ad vivum*, which they associated strongly with making a "true portrait" of nature.

The story of Dürer's rhinoceros points to several important aspects of the relationships among art, science, and commerce in Europe that will be considered in this volume. Renaissance and post-Renaissance western Europe played a unique role in the development of various arts and sciences devoted to the imitation of nature. The fact that they did this during the same time that Europeans expanded overseas had profound consequences for Europe and the world. Early modern Europeans sought to master nature through technology on an unprecedented scale, making the conquest of nature a political imperative from the sixteenth through eighteenth centuries.[7] Their activities resulted in the development of various arts and sciences devoted to the imitation of nature, the emergence of new conceptions of nature that responded to political and material changes, and a new discourse about nature that would become a central cultural force in Western society. But these results did not emerge *sui generis*, and we need to understand better the interconnections among diverse aspects of the project of understanding, describing, and conquering nature in order to appreciate fully the significance of these new developments.

During the early modern period a profound transformation in attitudes toward the natural world, the material environment, and their artistic representation occurred within a new environment of global trade and imperial ambitions in which commodities were produced, accumulated, consumed, and exchanged. The essays that make up this book explore many intersections between these developments, such as those suggested by Dürer's rhinoceros. One main conclusion of these essays concerns the importance of the coexistence of patronage and commerce in the early modern period and the way in which these overlapping social and economic systems of establishing value and significance resulted in an expansion of cultural production that greatly encouraged the investigation of and familiarity with nature. In addition, patronage of and commerce in the representations of nature in both art and science raised the status of individuals who claimed to imitate nature, such as many of the artist-artisans, medical practitioners, and other investigators of nature discussed in this book. This volume argues that these individuals helped lay the foundations of the new philosophy, which eventually would come to be called "science." This new natural philosophy, pursued with increasing enthusiasm in the late sixteenth and seventeenth centuries, emphasized practice, the active collection of experience, and observation of nature. One of the central goals of this volume is to invite readers to consider how a greater awareness of the importance of commerce in relation to scientific and artistic representations of nature and the growth of new technologies transforms the conventional story of the Scientific Revolution.

The genesis of Dürer's drawing of the rhinoceros illustrates the interpenetration of gift and commodity exchange in this period. As Europeans sailed down the coast of Africa, around the Cape of Good Hope, and finally across the Atlantic, the world changed. In 1601, as Deborah Harkness notes in her essay here, John Wheeler wrote that "all the world choppeth and changeth, runneth & raveth after Marts, Markets and Merchandising, so that all things come into Commerce . . . [and] all that a man worketh with his hand or discourseth in his spirit is nothing els but merchandise." Like many early modern Europeans, Wheeler was acutely aware of the fact that political, economic, and material changes were also remaking the world of knowledge and culture. How did commodification affect objects and attitudes to nature in early modern Europe? Traditional accounts of the new world of wealth in early modern Europe have drawn a stark contrast between the nobility and the bourgeoisie, seeing them as enmeshed in two different systems of production and as representing two contrasting types of economic actors who inhabited divergent cultural environments. Norbert Elias[8] and Otto Brunner,[9] for example, adduced evidence to show how attitudes to money wealth on the part of the nobility contrasted with that of the bourgeoisie. Marcel Mauss[10] distinguished between the feudal gift economy, permeated with notions of natural values, and the burgeoning new commercial economy, which assigned value to things based on their labor cost, giving them, in Marxian terms, an "unnatural," "fetishistic" value. In this view, nobility and bourgeoisie were enmeshed in two separate systems of exchange—one a world of gifts and favors, and the other a world of cash and commerce.

These categories have been used particularly in examining the activity of collecting. For example, Kryzstof Pomian places the "semiophore-man" (whose objects are "priceless" and bear only mystical significance because they point to the invisible) at one end of the spectrum and the "thing-man" (whose objects are worth only their economic value and thus are not priceless because they reflect only what is visible) at the other end.[11] We might conclude from these arguments that noble objects were taken out of economic circulation and thus did not belong to the same category as the bourgeois commodities. We might even conclude with Max Weber that the material accumulation of Calvinist Holland was a completely different enterprise from the material accumulation of Catholic princes. An initial examination of the activity of collecting appears to confirm this conclusion. The Habsburg *Kunstkammern* of the sixteenth and seventeenth centuries, for example, were intended to establish the *fama* of the ruler, representing his majesty (being shown to the most important "public" at court—visiting

nobles and ambassadors—and being displayed at *Schauessen*, or banquets) and wealth.[12] As an encyclopedia and memory theater of all nature, art, and knowledge, the *Kunstkammer* represented a theater of the world, demonstrating the ruler's mastery of nature. The cosmic themes of these *Kunstkammern* are clear from the decorative scheme in the Prague *Kunstkammer*, for example, which included the seasons, the months, the elements, and the planets, with Jupiter reigning over all in the center. Like many of the paintings commissioned by the Habsburg, their *Kunstkammern* can be read as imperial allegories, representing the ruler's symbolic mastery of the world.[13]

Collections in mercantile Holland in the seventeenth century, on the other hand, like many collections in Italy in the late sixteenth century, were filled with natural things. A survey of ninety Amsterdam citizens reveals that their collections were overwhelmingly made up of *naturalia*, followed closely by prints and paintings,[14] many of which were representations of natural and artificial objects. These collections grew largely out of the "professional" activities of doctors, apothecaries, and faculties of medicine at various universities. By the seventeenth century, however, much of these *naturalia* were natural objects turned commodities, such as shells whose price increased in direct proportion to the rarity of their shape and color. In Amsterdam, exotic plants were traded, collected, and sold in special shops that carried only East and West Indian curiosities. Even paintings could be used to buy "real" property such as land and houses. Neither curiosities nor paintings existed only in the realm of pure representation; they also played an active role in the world of commerce. Everything, it appears, could be bought and sold and given an equivalent value in relation to other goods in the marketplace.

But if we look more carefully at practices of collecting, we find that the situation is far less polarized between noble and bourgeois than appears at first glance. The "commodity collections" of the Dutch burghers did not possess only commercial significance, and in fact they were inferior to the princely collections as investments, for they seldom even fetched their calculated value at auction,[15] while noble collections were far more convertible into commodity value. Nobles collected the old-fashioned commodities of gold and silver, and pieces were not infrequently melted down in times of need, as the famous story of the bronze for Leonardo's equestrian monument of Francesco Sforza reminds us on an even larger scale. Perhaps the important thing to keep in mind is the very instability of these categories since the same object could serve multiple purposes. And both the Dutch commodities and the noble "potential commodities" (to borrow a phrase from the very stimulating work of Arjun Appadurai on commodities) could function as gifts at certain times and as commodities at others. Bourgeois collections functioned perfectly well within a gift economy,[16] and both types of collections had representational value.

Furthermore, although much has been made of the practical bent of Dutch scientific and artistic activity, as of that of their Italian predecessors, even the Habsburg *Kunstkammern* in the sixteenth and seventeenth centuries possessed a utilitarian and practical side (and had a number of leading northern European artists and naturalists employed on the emperor's behalf when they were not in places such as Leiden). Collections contained instruments used to survey noble lands; and painters were often sent to record aspects of forests, villages, and towns in a ruler's domains because they had special skills in representing their patron's dominion. The gardens, ponds, menageries, workshops, observatories, and libraries were used by artisans, artists, humanists, and natural philosophers for models, for the raw materials of knowledge and theories, and as part of an effort to classify and categorize.[17] Moreover, princes frequently showed as much interest in the new natural philosophy as citizens of republics and patronized some of the most important natural philosophers of the sixteenth and seventeenth centuries. Some nobles might have been more interested in display than others, but Landgrave Moritz of Hesse-Kassel, to name one, was more interested in arcane knowledge and processes.[18] At the same time, some of the encyclopedic collections of the northern Netherlands were not so much "professional" collections but results of the activities of rich merchants playing the *honnête homme*, such as Jan Six and Joachim de Wicquefort, and in certain ways, Rembrandt van Rijn, and, before him, Albrecht Dürer himself.[19] Indeed, Mark Meadow's essay places the merchant Hans Jacob Fugger squarely within the genesis of the central European *Kunstkammer*.

Whether noble or bourgeois, however, the objects in each collection pointed to their context: the items in Dutch collections represented objects available to moderately wealthy individuals living in a society enmeshed in a network of global trade. This fact, however, did not obscure other meanings: religious, moral, philosophical, and professional meanings intermingled with the commercial significance of a collection, and the alchemy among them depended to a large extent upon the intent of the collector.[20] While the social structure thus left its traces upon the collection, it did not determine entirely the value or meaning of the object. We must conclude along with more recent literature that commodification of natural objects was neither a sudden nor an absolute process, nor one that caused incommensurable disjunctions in society and culture.[21] In this vein, John Frow has suggested that commodification can be both enabling and productive as well as limiting and destructive. According to his argument,

> The commodity form does three things. First, it channels resources of capital into an area of production in order to expand it to its fullest capacity, at the same time destroying all productive activities which are not them-

selves commodified. Second, it transforms the purpose of production away from the particular qualities of the thing produced and toward the generation of profit; production is the indifferent medium for capital valorisation, and the qualities of the thing produced are incidental to this end. Third, it transforms previously or potentially common resources (both raw materials and final products) into private resources; the allocation of these resources normally takes place according to economic criteria (ability to pay rather than moral or civic entitlement), and it may be either restrictive or expansive in its effects. In the case of most cultural production—for example of books, perhaps the oldest of all commodities . . . which would not have come into being without extensive capital investment—the effects of commodification have been massively expansive.[22]

Historians could argue that at least the first and the third of his effects of commodification applied to patronage in early modern Europe. Recent scholarship on Renaissance consumption, particularly by Richard Goldthwaite and Lisa Jardine, has begun to document the way in which patronage, the gift economy, and commodity exchange all contributed to the expansion of cultural production beginning in the Renaissance.[23] The intersection between patronage and commerce in this period seems to be one key to the amplification of value and cultural significance that certain types of natural and artificial objects and modes of representing nature underwent.

VISUALISING NATURE

Dürer's rhinoceros also points to a new mode of description, which, even when not entirely precise, appeared to be the authentic result of a new emphasis on first-hand observation. Commerce clearly brought to light novelties, and novelty helped occasion new modes of description. The Spanish civil servant Gonzalo Fernández de Oviedo (1478–1557) lamented that he did not have a famous artist with him to record the things that he described in his natural history of the Indies in the early sixteenth century: "It needs to be painted by the hand of a Berruguete or some other excellent painter like him, or by Leonardo da Vinci or Andrea Mantegna, famous painters whom I knew in Italy."[24] In so saying, he articulated the importance of art in rendering knowledge visible for an audience fascinated by nature. Words alone could not adequately represent the marvels of the New World for a European audience. They needed to see these strange and different things in order to comprehend them fully. Fernández de Oviedo was not alone in believing that the skills possessed by Italian Renaissance painters versed in the new science of painting, as articulated by theorists such as Leon Battista

Alberti, would convey aspects of the Indies that verbal representation alone could not capture.

In 1543, the same year that Andreas Vesalius's *De Humani Corporis Fabrica* revolutionized anatomical imagery, Leonard Fuchs published 512 woodcuts of naturalistic plant specimens in *De Historia Stirpium*. He defended his departure from ancient practices:

> Though the pictures have been prepared with great effort and sweat we do not know whether in the future they will be damned as useless and of no importance and whether someone will cite the most insipid authority of Galen to the effect that no one who wants to describe plants would try to make pictures of them. But why take up more time? Who in his right mind would condemn pictures which can communicate information much more clearly than the words of even the most eloquent men? Those things that are presented to the eyes and depicted on panels or paper become fixed more firmly in the mind than those that are described in bare words.[25]

But naturalistic representation, appearing first in northern Italy and then in Flanders, was more than pictorial description. In the course of the fifteenth century, it became a fashion. The particularistic naturalism of Flemish painters, such as Jan van Eyck and Robert Campin, that emerged out of the forced integration of French court culture and the indigenous urban artisanal style of the rich trading cities of the Lowlands, spread rapidly to the noble courts and burgher homes of other parts of Europe.[26] Likewise the peculiar version of naturalism that we associate with Tuscan art between the age of Brunelleschi and Leonardo also found its following in many other parts of Italy in the course of the fifteenth and early sixteenth centuries, and influenced important northern artists such as Dürer.[27] Naturalistic images and natural objects became sought-after objects of patronage and commerce among European nobility and wealthy burghers. In many cases, it is not clear that the object was necessarily preferred over the image. A series of images created an aesthetically pleasing archive of the world that the diversity and fragility of actual artifacts never seemed quite able to capture—which is why "paper museums" such as Ulisse Aldrovandi's collection of thousands of naturalistic drawings and John White's illustrations of North America continue to be fundamental resources for our understanding how early modern Europeans saw and understood their world.[28] For this reason, we should take seriously the role of images in generating a new sense of the natural world, while at the same time preserving traditional images of nature that were less easily rendered as objects because they were acts of imagination.

Dürer's nature studies, which both continued and extended the Flemish innovations of the previous century and benefited from parallel developments in Italy, helped fuel a fashion in the description of nature. In the generation following Dürer, we find "amateur" botanizers and artists who self-consciously became his followers in cities such as Nuremberg, just as we can find communities of artists deeply influenced by Leonardo's style in the vicinity of Milan. They painted insects, small animals, and flowers in imitation of Dürer, but interestingly, they also went out into nature to find subjects for their visual descriptions.[29] The passion for a new kind of naturalistic art had indeed inspired artists, naturalists, and patrons to invest in the objects they sought to represent. It brings to mind the comment of the Veronese apothecary Francesco Calzolari, collector of art and nature and a famous botanist in the late sixteenth century, who told his fellow naturalists that when they climbed to the top of Monte Baldo near Verona the landscape that they would see resembled "a most beautiful Flemish painting."[30]

In the sixteenth and seventeenth centuries, the things of nature and their naturalistic representations were collected, studied, sold, and consumed all over Europe; objects and images claiming to portray and describe nature became a desired fashion, hard to obtain, and sought by princes and scholars for their cabinets of curiosities. The correspondence of the Augsburg merchant Philipp Hainhofer (1578–1647), an agent to several German princes, provides numerous examples of the passion with which naturalistic objects and images were sought. He often praised the "lifelikeness" or "naturalness" of an image or sculpture to his noble patrons.[31] Small animals cast from life in which "nothing is carved, but all is cast after life [nach dem leben]" were especially highly prized.[32] In one case, he even called in medical doctors to attest to the verisimilitude *and* aesthetic effect of a corpse sculpted in wax.[33] In his correspondence, Hainhofer both responded to *and* consciously trained the taste of his patrons (who, as his increasingly frantic attempts to obtain payment indicate, were simultaneously his clients).[34]

The fascination with natural goods and artificial objects made after nature that Hainhofer and others both ministered to and fostered, had the effect of disseminating images of nature, increasing familiarity with nature, and training a taste for naturalism. As Hainhofer was selling naturalism to his northern patrons, Galileo Galilei used naturalistic images in his attempts to convince his "image-friendly" patrons of his claims that the surface of the moon was irregular and imperfect (fig. Intro. 2).[35] We see here another of the effects of the fashion for naturalism that is discussed in the papers in this volume: the formation of a new visual language that would eventually become an auxiliary tool of proof in the natural sciences.

The natural and artificial objects and their images that were brought to the fore by the lively trade in early modern Europe constituted a sustained

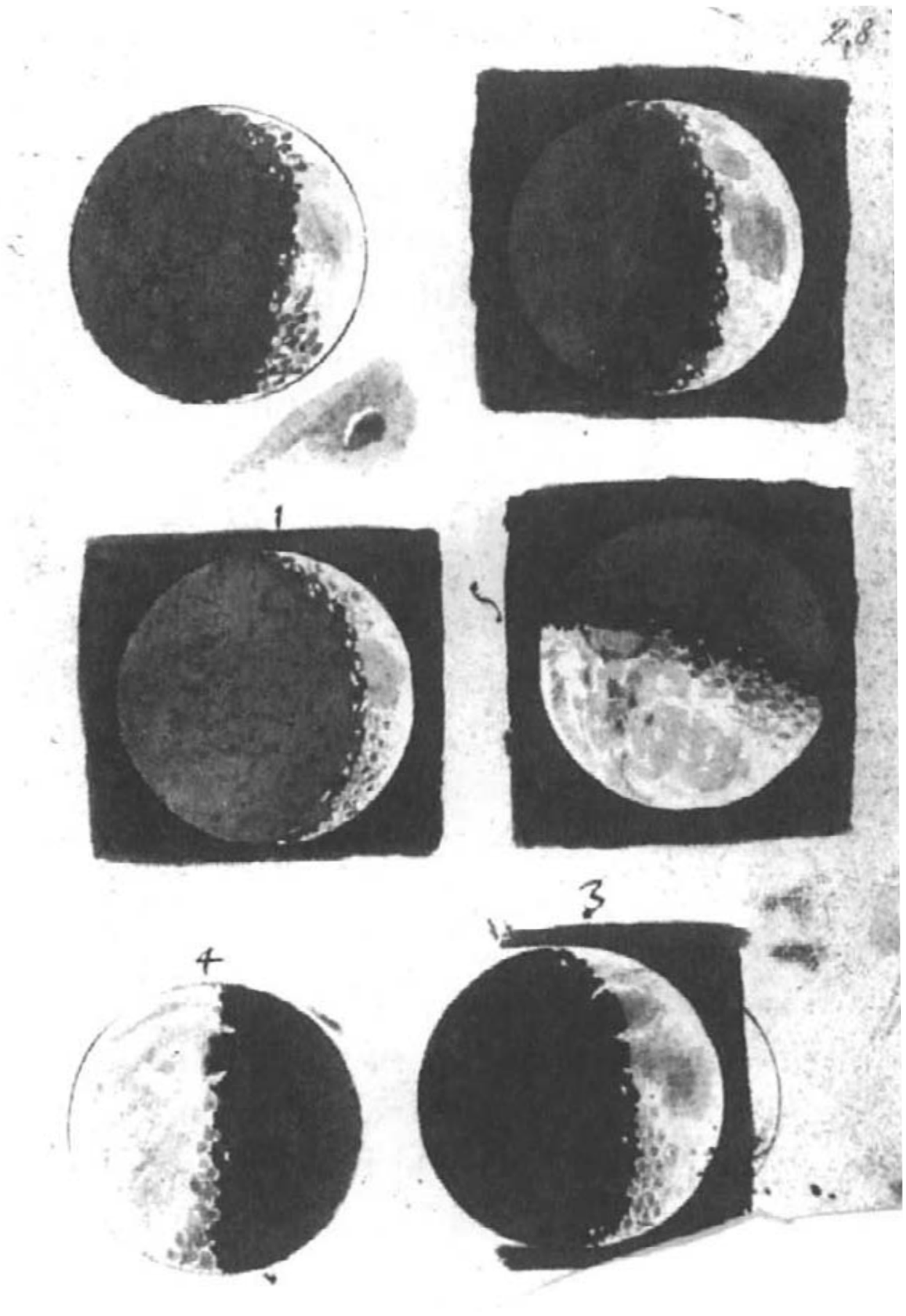

Figure Intro.2
Galileo Galilei, "Moon Surface" preparatory drawing for *Sidereus Nuncius* Ms. Gal. 48, fol. 28r. Courtesy of the Biblioteca Nazionale, Florence.

meditation on the boundary between art and nature and on the human capability of transcending this boundary.[36] This meditation went on in artists' workshops, natural philosophical cabinets and academies, and in noble collections and *studioli*. Ultimately, this taste for and interest in nature and naturalism trained the senses. By means of this circulation of naturalistic objects and images, some people learned to observe, record, compare, and, above all, value positively such acts of description, comparison, and recording. The patronage *and* the commodity value of these goods created a climate favorable to the investigation and representation of nature and helped to raise the status of the imitators and knowers of nature. As Claudia Swan has written

> Throughout the sixteenth century and well into the seventeenth, observation, description, and accumulation were the means by which nature came to be ever more systematically encountered, cataloged, published, collected, and studied. The epistemological objectives sponsored a particular kind of image, an image done *ad vivum*.[37]

We might simply say that the peculiar confluence of events made realistic naturalism a model of representation and a measure of the actual objects that were drawn and sculpted in various media. But the important thing to bear in mind is the lesson of Dürer's rhinoceros: such images were deeply enmeshed in political and commercial networks that looked at nature in new ways because it was a tangible sign of one's mastery of the world.

PRODUCING KNOWLEDGE

The turn to naturalism in art reflected a fairly sudden and dramatic transformation of the ways in which European artists represented their world. Its history, particularly in northern Italy and Flanders in the 1400s, has often been recounted in an heroic mode that tends to assume the value of naturalism without exploring what values it reflected at the time. In discussing the remarkable naturalism of the illustrations of the manuscript *Carrara Herbal* of around 1400 (fig. Intro 3), for example, Otto Pächt spoke of the illustrator's "courage to turn his back on all patternbooks and to look nature straight in the face."[38] Similarly, Erwin Panofsky commented on the principle, new in the Renaissance, that a work of art should be a faithful representation of a natural object, writing, "Treatises on sculpture and painting, therefore, could no longer be limited to supplying generally accepted patterns and recipes but had to equip the artist for his individual struggle with reality."[39] This heroic tone might remind us of old narratives of the Scientific Revolution, in which the protagonists finally looked at nature and saw what was "really" there. More recent scholarship has reminded us that naturalistic images did not always imply a theoretical commitment to observing nature for its own sake. The meditation on the boundary between nature and art sometimes produced witty counterfeit images, such as Joris Hoefnagel's imaginary insects that played with viewer's presuppositions about verisimilitude.[40] Just as the history of art has developed a more sophisticated approach to the idea of naturalism, likewise the history of science no longer confines itself to a simple story of seeing what was "really" there. These heroic narratives, however, both speak to the ways in which both modern techniques of representing reality and the advent of a new science traditionally have symbolized the break with the past that observers have discerned between the "premodern" and the "modern." The similarity of these two stories and the coincidence of their arrival make us want to see a connection between a deeper interest in nature that seems to be manifested in naturalistic art and the investigation of nature by the "new philosophy." What connections can we draw between the emergence of the new practices vis-á-vis the natural world and the new naturalistic representation?

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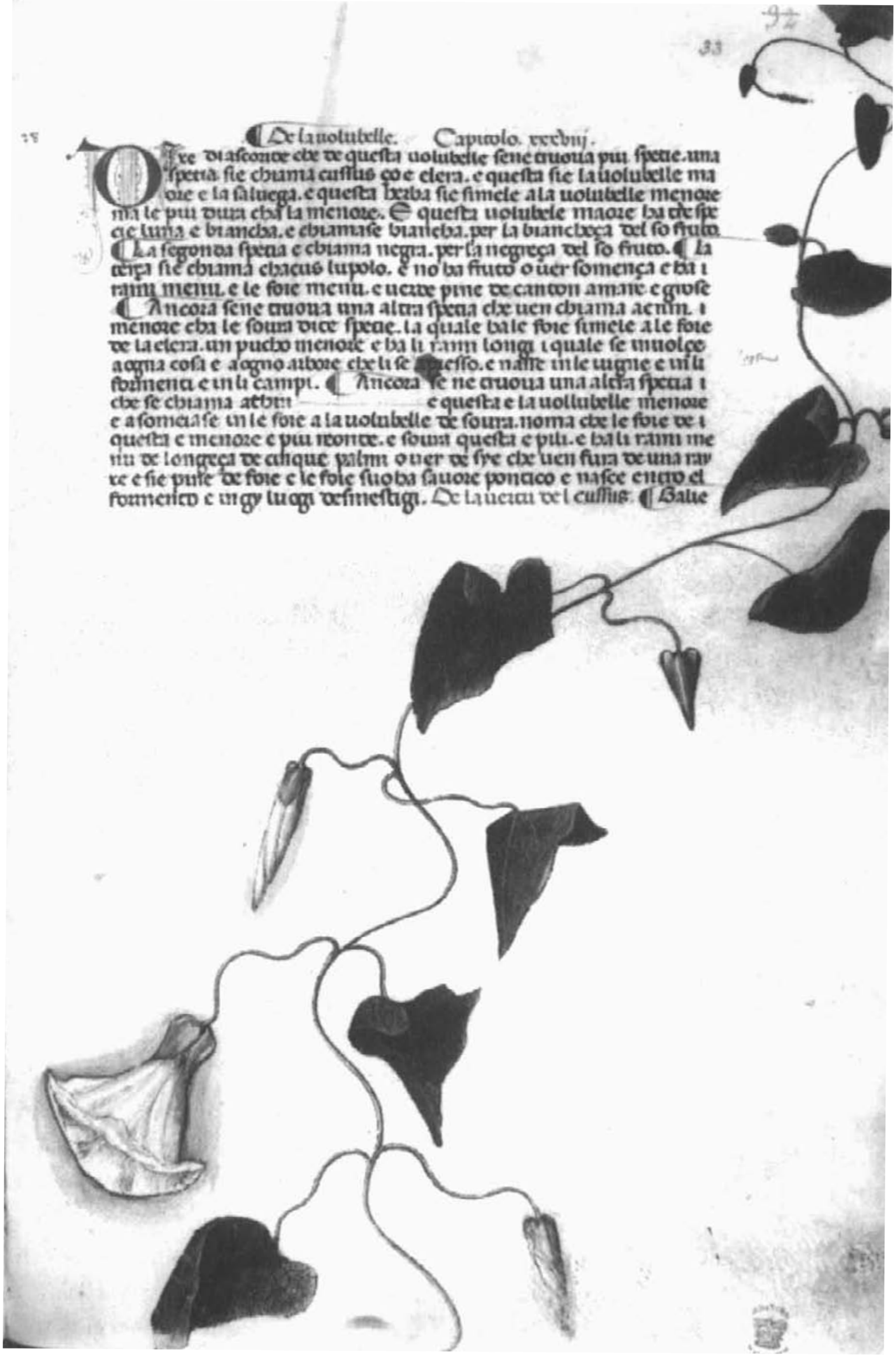

Figure Intro. 3 Carrara Herbal, *Convolvulus*, ca. 1400, Egerton 2020, f. 33.
By permission of the British Library.

If we look again to Dürer's rhinoceros and recognize the central role he played in disseminating its representation along with other naturalistic images, as well as in establishing a standard and technique of naturalism, we can begin to understand the central role that artisans in the fifteenth and sixteenth centuries played in shaping new modes of description of and new attitudes toward nature. The artisan, after all, was neither wholly an artist nor a technologist in a modern sense but a person with skills that traversed these seemingly different domains. The history of many scientific instruments, such as the telescope, the camera obscura, and the microscope, and their relationship to new techniques of observation indicate similar conclusions. All of these instruments emerged from artisanal and mercantile milieus. Their application and dissemination also reflected the abilities of individuals in early modern society to cross boundaries that we have since installed by creating disciplines in areas which were predominantly defined by skills and techniques rather than specific kinds of knowledge.

Historians of art and of science have treated the convergence between artists-artisans and natural philosophers at length.[41] The subject of perspective, for example, and its mathematical construction has proved to be a *locus classicus* for such interdisciplinary discussions. James Ackerman has made clear the importance of the interaction between craftspeople and scholars in the matter of scientific illustration; Svetlana Alpers has proposed a more diffuse shared sensibility of descriptive analysis that functioned as a "two-way street" between which natural philosophers and artisans traveled in the sixteenth and seventeenth centuries;[42] and Thomas DaCosta Kaufmann has shown in depth the overlapping worlds of humanists and artists in the Holy Roman Empire.[43] In *The Science of Art*, Martin Kemp reconstructs a rich dialogue between artists and naturalists across several centuries, particularly in the matter of perspective construction and the use of lenses, although he concludes that there was no parity and no causal link between realist "art" and realist "science" in the early modern period because science seeks explanation and art seeks to create illusion.[44] Kemp expresses a loosely held consensus among historians of art and science that the investigators of nature and artists shared affinities, but not more. Recent research suggests that we should push this argument further. While the opposition between art and science as two different modes of engaging nature may be true in some sectors today, in the fifteenth and sixteenth centuries, when the methods of the new science were being constructed, artist-artisans were engaged in a kind of philosophizing about nature, and, while so engaged, they articulated a body of claims about nature and about the nature of authority that helped form the basis of the new science.[45]

Panofsky's phrase "the struggle with reality" resonates in this context, because early modern artists, artisans, and natural philosophers were indeed

grappling with the problem of what the world really was and how they ought to see it, understand it, and represent it. How could they wrest knowledge, sometimes by bodily force, from nature? How could the information they gained through their senses give them reliable knowledge of nature? And how could they turn that knowledge to the production of works (of art, of technology, or of natural knowledge)? Both artisans and natural philosophers needed such knowledge; they needed to learn by the repeated experience of apprenticeship the characteristics of the material they worked and thus to produce masterpieces, or, in the case of architects and engineers, to build fortresses, canals, and weapons, or, in the case of physicians and natural philosophers, to produce medicaments and knowledge from nature. Moreover, both groups were engaged in a struggle to make sensory knowledge of nature authoritative; that is, they themselves had to gain social authority in order to formulate a picture of the real.[46] Early modern artists and naturalists alike required this social authority and self-consciousness in making the products that resulted from their efforts attractive and persuasive in a marketplace of goods and services that had no obligation to privilege their vision of reality. Practitioners of art and science, then, were both engaged in a quest for new methods of representing nature, as well as representing themselves as representers of nature.[47]

Several essays in the first section of this volume explore the relationship of artists and artisans to nature, and the way in which their values were absorbed into the new philosophy of nature. They make the point, however, that this was not in any way a linear and uncontested process. In the world of fifteenth-century artisans, artists, and natural philosophers we can see how much figures such as Leonardo and Dürer helped to shape subsequent discussions of representing and understanding nature without in any way determining the outcome of the conversation. Moving into the sixteenth century, in a world of learned naturalists such as Leonhart Fuchs, Conrad Gessner, and Ulisse Aldrovandi who created communities of artists around their projects of nature, we see a new set of emerging relations between the artistic, artisanal, and philosophical communities, as each of these groups underwent significant transformation. By the seventeenth century, an artist-naturalist such as Maria Sibylla Merian could travel all the way to Surinam, following the trade routes that had created this Dutch colony in the Indies, in order to pursue the insects that she wished to represent.[48] None of the groups that created the intersections among art, nature, and commerce enjoyed a well-defined or even very stable role. If artists played a dramatic role in ushering forth a new image of the world, naturalists took credit for cataloging the many variations of nature and using the medium of the printed natural history to combine words and images. Likewise the merchants and princes who understood the economic value of nature and of new

technologies shaped the material environment in which it became possible, even necessary, to create a new art and science of description.[49]

NETWORKS OF KNOWLEDGE: THE MARKET FOR ART, THE COMMERCE OF SCIENCE

Art historians have argued that the rise of commerce, as well as the commerce in paintings themselves, brought about changes in style and subject matter. Michael Baxandall famously showed the ways in which the "dancing bankers" of Renaissance Florence changed the face of art.[50] Following some of Baxandall's fundamental insights, Richard Goldthwaite has argued that mercantile and patrician demand for certain kinds of art and architecture played an important role in the development of Italian Renaissance art. John Michael Montias has argued that market demand for paintings in the Dutch Republic led to workshop innovations that brought about greater production, such as the move from fine, detailed, smooth work to quick, rough, painterly techniques in the northern Netherlands in the 1630s,[51] and recent work on the art market in sixteenth-century Antwerp has greatly expanded our understanding of the way in which works of art became regular items of international trade.[52] The issues raised by these works have spawned a literature far too extensive to cover here.[53] Strangely enough, no similar literature on science and commerce exists. It is instructive to explore why this might be so.

Max Weber first linked the rise of science to the rise of capitalism early in this century, regarding such a connection as a by-product of the relationship between Calvinism and commerce.[54] According to Weber, Calvinism was one factor in the emergence of a psychological habit that led to an innerworldly asceticism that valorized the creation of wealth (as the work of Providence) and eventually resulted in a new rationality, thus tying both science and capitalism to the emergence of a religion of the bourgeoisie. The most famous result of Weber's link in the anglophone world was Robert K. Merton's 1938 monograph, *Science, Technology, and Society in Seventeenth-Century England*, which posited a link between Puritanism and the rise of modern science in the last half of the seventeenth century. Almost two-thirds of Merton's book dealt with the economic factors that made science a "socially countenanced, even esteemed" activity in seventeenth-century England.[55] The link between Puritanism and science came to be known as "the Merton thesis," but for Merton, it was not only Puritanism, but also the rise of capitalist economic activity and social structures that made, as he put it, the "cultural soil of seventeenth-century England peculiarly fertile for the growth and spread of science."[56] The subsequent debates over the "Merton

thesis," which occupied so many historians of science, dealt only with the link between Puritanism and science, and did not explore the link between capitalism and science.[57] The reasons for this neglect in anglophone history of science could well be the subject of an entire essay, but important factors include the prevalent influence in the United States and England of Alexandre Koyré's conceptualization of the scientific revolution as a revolution in theory—primarily in astronomy and physics. The professionalization of historians of science that occurred in the United States separated business historians and historians of technology into separate professional societies and discouraged greater consideration of technology and science in their common relation to commerce. No doubt the distaste for examining the social and material relations of scientific knowledge owed something as well to the Cold War.[58] The result was that important scholars of the Scientific Revolution distinguished sharply between the classical, mathematical sciences and the experimental sciences, or the mechanical arts, which they regarded as tied to commercial ends and uninfluential in the Scientific Revolution.[59]

This bifurcation has begun to break down as historians of science, influenced by cultural history and its emphasis on practices, have focused on "practitioners." The old story of the Scientific Revolution was largely the story of theoretical change, in which the story of the invention of "experiment" was also important but was written as the intellectual history of a practice.[60] This story left out the large numbers of individuals who began to show interest in and to practice the "new philosophy," and whose actions brought about the institutionalization of the new philosophy, and, more important, made the new method of pursuing knowledge part of the habits of mind and action of European culture. One of the central components of the Scientific Revolution is now seen to be the emergence of a whole new set of beliefs about, and practices involving, nature. The pursuit of natural knowledge became *active* and began to involve the body; the investigator of the natural world had to observe, record, and engage with nature. This new active element of philosophizing about nature led Francis Bacon to call it a "New Philosophy, or Active Science." "Active science" was for Bacon an oxymoron.[61] Furthermore, one of the aims of this new pursuit of the knowledge of nature consisted in the production of effects—tangible objects or observable phenomena. An important source for this new epistemology was the entry into the knowledge-making process of a new group of people, practitioners, drawn from all social strata, but often occupying a middle ground between university-trained scholars, immersed in texts, and workshop-trained artisans, immersed in a world of technique. These practitioners often saw natural knowledge as an arena in which they could gain new authority and legitimacy. It brought them the attention of humanists, gave them access to the republic of letters, and bestowed upon them the favor of

princes, all predicated not upon their birth nor upon their knowledge of elite learning, but instead upon their ability to undertake particular practices and produce tangible effects or objects. All these practitioners are relative newcomers to the historiography of science, or perhaps a shadowy presence that has always been there but without a clearly delineated role. When we view them as part of the story of the emergence, or, better, the *construction* of science, the connections between early modern natural philosophy and commerce jump out at us with striking clarity. Recent historiography of science has found natural philosophy in new places, and has advanced the argument that entrepreneurial doctors, Spanish juntas, foreign artisans in England, and scholarly merchants all helped shape the habits of mind and action that became the new science.[62] This volume brings together many examples of this recent literature and places it next to a similar set of intersections that have been articulated in the history of art and science.

It is particularly illuminating that for many of these practitioners, attention to nature and to the market sprang from their interest — in both its intellectual and financial senses — in medicine. Recent work on natural history demonstrates the importance of medical practitioners in formulating, articulating, and disseminating the new philosophy.[63] Nor should this surprise us. Medicine always had some manual component to it, and physicians were always involved with the preparation of medicaments, combining theory and practice in a way that would eventually characterize all natural philosophical activity. Moreover, apothecaries and herbalists had long claimed direct access to nature and were among the first to concern themselves with the relationship between word, image, and nature in herbals and other health-related texts.[64]

The essays in the second section of this volume show us just how many individuals in sixteenth- and seventeenth-century Europe were engaged quite straightforwardly both in commerce and the pursuit of natural knowledge, and how many of their scientific ideas and practices had perfectly clear and calculable economic value that could be offered on the market. They make the point that, in some contexts, considerations of use and profit were the main stimulus to the investigation that yielded new "matters of fact" from the sixteenth to the late seventeenth century.[65]

The chapters in this section also show how pursuit of imperial power — and the desire for domination over nature and peoples and their exploitation for income — is integral to the construction of a new mode of rationality; one that stressed eyewitnessing, close observation, group judgment and evaluation of information, and the disciplining of subjects. Anthony Pagden has written very suggestively about the formation of this rationality, making the point that a variety of strategies were used to give authority to these new methods. For example, authors created new genres, often modeled on the

natural history of Pliny, they used a new plain prose style, and they often employed the legal category of "fact."[66] The ancient genre of natural history turned out to be a remarkably accommodating rubric under which to ascertain the truth of nature in the service of empire. As Chandra Mukerji shows in this volume, strategies of domination in the seventeenth-century French kingdom also brought to the fore certain practices in relation to nature.

These essays give us the material to conceive of early modern science in new ways and to construct a new social and cultural narrative about the transformation in attitudes to the material world that is sometimes called "the" Scientific Revolution. The story told in the pages that follow includes many more people—ranging from indigenous New World artisans and informants, to Spanish and English bureaucrats, Jesuit missionaries, counterfeiters, and a multitude of others. It brings to light some of the early and explicit connections between political power and knowledge of nature, between the universalist claims of science and those of empire, and between social practices and modes of thought. In contrast to the scholarship that followed Merton, the essays in this volume suggest that it is in fact now difficult to overestimate the importance of the link between science and commerce.

CONSUMPTION, ART, AND SCIENCE

Fernández de Oviedo's desire, quoted above, that an artist would supplement his verbal description of the wonders he encountered, is one obvious link between art, science, and commerce, but a more profound connection between these three areas can be found in their intersection in the body: in sensory observation and sensual consumption, in the use of the senses to know nature, and in the sensory enjoyment of the things of nature and art. Sensuality, desire, and the passions were intimately linked to commerce, and the passions played a part in sensory perception. The first of the passions was curiosity, said by Descartes to be the beginning of knowledge, and it was also the engine that drove the collection and trade of the objects of nature and art.[67] One key to the relationship between commerce, art, and science lies here, in the relation of human bodies and their sensory organs to the material world. The essays in the final section of this volume discuss the connections between consumption and the representation of nature.

Curiosity and the search for profit were insatiable and omnivorous, and the investigation of nature, the creation of art, and commercial exchange were all deeply affected by a new valuation of curiosity in the early modern period. As Lorraine Daston has shown, curiosity moved from an alignment with lust and pride to one with avarice in the early modern period, and this

new sensibility oriented scientific investigation toward commodity-like objects, as well as into the hidden secrets and small things of nature. Curiosity drove collection and consumerism, as well as serious scientific inquiry, as was attested to by Isaac Newton, Robert Hooke, and Marin Mersenne.[68] Dürer too, felt his portrayal of the rhinoceros was compelled by curiosity and wonder: "Because it is such a wondrous thing, I had to send you a portrayal made after it (Das hab jch dir van wunders wegen müsen abkunterfet shicken)."[69]

Much work remains to be done in writing a history of the body and the passions in relation to scientific investigation, and the relationship of art, science, and commerce is just one of the areas that will be clarified by such a history. The history that this volume seeks to recapture is not a neatly unified account of the early modern world, but a series of uneven developments — fascinating intersections that emerge when different disciplines discuss the meaning of nature and experience, knowledge and profit, money and materialism in the early modern period. Each contribution highlights a different kind of intersection that defines the world of "merchants and marvels" in the late fifteenth through late seventeenth centuries. They remind us of the importance of careful comparative analysis, lest we be too quick to offer a global definition of any of these categories. Finally, they reflect a new geographic sensibility about the study of science and culture in early modern Europe, one that places as much emphasis on countries such as Spain and the Netherlands as it does on more traditional sites for the Scientific Revolution, such as Italy, Germany, and, above all, England. New questions come from historians' and art historians' interest in new materials. And they also arise from our interaction with old debates — the incomplete vision of science and technology offered by Merton, for example, or the suggestive account of artistic naturalism proposed by Pächt and revised by Baxandall, Alpers, and Kemp. Let us imagine Dürer as he traveled through Europe, carrying the image of a rhinoceros that never arrived. But of course it did — and that is the point of the story.

Notes

1. Silvio A. Bedini, *The Pope's Elephant* (New York: Penguin, 1997).

2. T. H. Clarke points out that prior to the rhino's arrival in Lisbon in 1515, only a few classical scholars and humanists would have been familiar with the animal, from Roman coins, cameos, and Pliny's account. T. H. Clarke, *The Rhinoceros from Dürer to Stubbs, 1515–1799* (London and New York: Sotheby's Publications, 1986), 16. It is most likely that Dürer's drawing and woodcut are based upon a sketch that accompanied a newsletter sent to Nuremberg in 1515 by the Moravian printer Valentin Fernandes, who worked in Lisbon.

Shortly after the original drawing was made and certainly before his death in 1528, the first edition of the woodcut was published. Second and third editions were published in the 1540s–1550s, and it seems that these editions were the ones widely circulated and iconographically influential to later artists. The drawing and woodcut are characterized by decorative and imaginative patterning upon the separate plates of the rhinoceros's body. In 1515, Dürer lived in the street next to the armorers' quarter (the Schneidgasse) in Nuremberg and was actively producing designs for armor. Clarke notes that this patterning bears strong resemblance to Dürer's armor designs of the same period and compares it particularly to his sketch *Visor for a Jousting Helm*, ca. 1515.

3. This inscription written below the image in Dürer's hand is likely a transcription of Fernandes's newsletter account. John Rowlands, *The Age of Dürer and Holbein: German Drawings 1400–1550* (London: British Museum Publications, 1988), 94.

4. Peter Parshall, "Imago Contrafacta: Images and Facts in the Northern Renaissance," *Art History* 16 (1993): 554–579 .

5. Dürer very early on recognized the commercial potential of the new medium of the printing press, writing, "From now on, I shall concentrate on engraving. Had I done so all the time I should today be richer by a thousand guilders." Quoted in Erwin Panofsky, *The Life and Art of Albrecht Dürer* (Princeton, N.J.: Princeton University Press, 1955), 44.

6. Martin Kemp, "'The Mark of Truth': Looking and Learning in Some Anatomical Illustrations from the Renaissance and Eighteenth Century," in *Medicine and the Five Senses,* ed. W. F. Bynum and Roy Porter (Cambridge: Cambridge University Press, 1993): 85–121.

7. Anthony Pagden, *European Encounters in the New World: From Renaissance to Romanticism* (New Haven, Conn.: Yale University Press, 1993).

8. Norbert Elias, *The Development of Manners*, Vol. 1 of *The Civilizing Process*, trans. Edmund Jephcott (New York: Urizen Books, 1978 [1939]); idem, *Power and Civility*, Vol. 2 of *The Civilizing Process*, trans. Edmund Jephcott (New York: Pantheon Books, 1982 [1939]).

9. Otto Brunner, *Adeliges Landleben und europäischer Geist. Leben und Werk Wolf Helmhards von Hohberg, 1612–1688* (Salzburg: Otto Müller, 1949).

10. Marcel Mauss, *The Gift*, trans. W. D. Halls (New York and London: W. W. Norton, 1990 [1950]).

11. Krzysztof Pomian, *Collectors and Curiosities: Paris and Venice*, trans. Elizabeth Wiles-Portier (Cambridge: Polity Press, 1990 [1987]). See also Antoine Schnapper, *Le Géant, La Licorne et la Tulipe: Collections et Collectionneurs dans le France du XVIIe Siècle* (Paris: Flammarion, 1988).

12. Thomas DaCosta Kaufmann has written eloquently on the political and representational goals of the central European *Kunstkammern* in *The Mastery of Nature: Aspects of Art, Science, and Humanism in the Renaissance* (Princeton, N.J.: Princeton University Press, 1993), especially the chapter, "From Mastery of the World to Mastery of Nature: The Kunstkammer, Politics, and Science," using the examples of the sixteenth- and early seventeenth century *Kunstkammern* of Emperor Rudolf II (1576–1612) and Archduke Ferdinand II of Tyrol (1529–95).

13. The collections of Ferdinand II of Tyrol in Schloss Ambras and those of the emperors in Vienna and Prague, the latter most famously enlarged by Rudolf II, were apparently arranged according to the material of the objects and grouped vaguely under *naturalia* (representing nature), *artificialia* (representing human art and the human place in the scheme of cosmic history as well as the mastery of nature by art), and *instrumenta* (representing human knowledge). See, among others, Christian Gries, "Erzherzog Ferdinand II. Von Tirol und die Sammlungen auf Schloß Ambras," *Frühneuzeit-Info* 5 (1994): 7–37.

14. Jaap van der Veen, "Dit klain Vertrek bevat een Weereld vol gewoel: Negentig Amsterdammers en hun kabinetten," in *De wereld binnen handbereik: Nederlandse kunst-en rariteit-*

enverzamelingen, 1585–1735, ed. Ellinoor Bergvelt, Renée Kistemaker (Zwolle: Waanders Uitgevers, 1992), 232–258. See also T. H. Lunsingh Scheurleer, "Early Dutch Cabinets of Curiosities," in *The Origins of Museums,* ed. Oliver Impey and Arthur Macgregor (Oxford: Clarendon Press, 1985), 116–120.

15. As was the case at the auction of the collection of Jan Swammerdam's father.

16. Arjun Appadurai, ed., *The Social Life of Things: Commodities in Cultural Perspective* (Cambridge: Cambridge University Press, 1986).

17. Kaufmann, *The Mastery of Nature.*

18. Bruce Moran, *The Alchemical World of the German Court: Occult Philosophy and Chemical Medicine in the Circle of Moritz of Hessen (1572–1632), Sudhoffs Archiv,* Supplement 29 (Stuttgart: Franz Steiner Verlag, 1991), and idem, "German Prince-Practitioners: Aspects in the Development of Courtly Science, Technology, and Procedures in the Renaissance," *Technology and Culture* 22 (1981): 253–274; Heiner Borgrefe, Vera Lüpkes, Hans Ottomeyer, eds., *Moritz der Gelehrte. Ein Renaissancefürst in Europa* (Eurasburg: Edition Minerva, 1997).

19. Dagmar Eichberger, "Naturalia and artefacta: Dürer's Nature Drawings and Early Collecting," in *Dürer and His Culture,* ed. Dagmar Eichberger and Charles Zika (Cambridge: Cambridge University Press, 1998), 13–37.

20. See *So wijd de wereld strekt* (The Hague: Mauritshuis, 1979–80).

21. See Appadurai, *Social Life*; Chandra Mukerji, *From Graven Images: Patterns of Modern Materialism* (New York: Columbia University Press, 1983); and Craig Clunas, *Superfluous Things: Material Culture and Social Status in Early Modern China* (Urbana: University of Illinois Press, 1991).

22. John Frow, "The Signature: Three Arguments about the Commodity Form," in *Aesthesia and the Economy of the Senses,* ed. Helen Grace (Kingswood, N.S.W.: UWS Nepean, 1996), 151–200, 192–193.

23. Richard A. Goldthwaite, *Wealth and the Demand for Art in Italy, 1300–1600* (Baltimore: Johns Hopkins University Press, 1995), and Lisa Jardine, *Worldly Goods: A New History of the Renaissance* (New York: W.W. Norton, 1996). See also the AHR Forum on the Renaissance, *The American Historical Review* 103, no. 1 (1998).

24. Fernández de Oviedo, *Historia General,* ii, 7, quoted in J. H. Elliott, *The Old World and the New 1492–1650* (Cambridge: Cambridge University Press, 1970), 21.

25. Leonhart Fuchs, *De historia stirpium comentarii insignes . . . accessit iis succincta admodum difficilium obscurarum passim in hoc opere occurrentium explicatio* . . . (Paris, 1543), Preface, pp. x–xi, quoted in James S. Ackerman, "Early Renaissance 'Naturalism' and Scientific Illustration," in *The Natural Sciences and the Arts: Aspects of Interaction from the Renaissance to the Twentieth Century: An International Symposium,* ed. Allan Ellenius (Uppsala: Almqvist & Wiksell, 1985), 1–17, 17.

26. Wim Blockmans and Walter Prevenier, *The Promised Lands: The Low Countries Under Burgundian Rule, 1369-1530,* trans. Elizabeth Fackelman (Philadelphia: University of Pennsylvania Press, 1999).

27. The classic study of this subject remains Michael Baxandall, *Painting and Experience in Fifteenth-Century Italy* (Oxford: Oxford University Press, 1972).

28. Giuseppe Olmi, *L'inventario del mondo. Catalogazione della natura e luoghi del sapere nella prima età moderna* (Bologna: Il Mulino, 1993); and Roger Schlesinger and Arthur P. Stabler, *Andre Thevet's North America: A Sixteenth-Century View* (Kingston, Ont.: McGill-Queen's University Press, 1986).

29. Heidrun Ludwig, *Nürnberger naturgeschichtliche Malerei im 17. und 18. Jahrhundert* (Marburg an der Lahn: Basilisken-Presse, 1998).

30. Francesco Calzolari, *Il viaggio di Monte Baldo* (Verona, 1565), 11.

31. A brief look at the correspondence of Philipp Hainhofer, the Augsburg merchant and princely factor, confirms this. For excerpts of his correspondence relating to art, see Oscar Doering, "Des Augburger Patriciers Philipp Hainhofer Beziehungen zum Herzog Philipp II von Pommern-Stettin. Correspondenzen aus den Jahren 1610–1619," *Quellenschriften für Kunstgeschichte und Kunsttechnik des Mittelalters und der Neuzeit*, NF Bd. 6 (Vienna: Carl Graeser, 1894).

32. Ibid., 79–82.

33. Ibid., 91.

34. From 1617, Hainhofer's demands for payment became urgent.

35. Mario Biagioli, "Picturing and Convincing: The Discovery and Illustration of Sunspots," unpublished paper read at the Clark Library, Los Angeles, October 2000.

36. Martin Kemp, "Wrought by No Artist's Hand: The Natural, the Artificial, the Exotic, and the Scientific in Some Artifacts from the Renaissance," in *Reframing the Renaissance,* ed. Claire Farago (New Haven, Conn.: Yale University Press, 1995), chapter 9, shows the various and interpenetrating values assigned to objects that teetered on the edge of the nature/art divide. See also Peter Parshall "Art and Curiosity in Northern Europe," *Word and Image* 11, no. 4 (1995): 327–331.

37. Claudia Swan, "Ad vivum, naer het leven, from the life: Defining a Mode of Representation," *Word and Image*, 11, no. 4 (1995), 352–372.

38. Otto Pächt, "Early Italian Nature Studies and the Early Calendar Landscape," *Journal of the Warburg and Courtauld Institutes* 13 (1950): 13–46, 31.

39. Panofsky, *Life and Art of Dürer*, 243.

40. In a study of herbal illustrations, however, Sachiko Kusukawa has pointed out that we should not assume that "naturalistic depiction implies a theoretical commitment to observing nature for its own sake." "Leonhart Fuchs on the Importance of Pictures," *Journal of the History of Ideas* 58 (1997): 403–427, esp. 427. Majorie Lee Hendrix, "Joris Hoefnagel and the 'Four Elements': A Study in Sixteenth-Century Nature Painting" (Ph.D. diss., Princeton University, 1984). Thomas DaCosta Kaufmann and Virginia Rochrig Kaufmann, "The Sanctification of Nature: Observations on the Origins of Trompe L'Oeil in Netherlandish Book Painting of the Fifteenth and Sixteenth Centuries," *J. Paul Getty Museum Journal* 19 (1991): 43–64.

41. Historians of science who have treated art and science include Giorgio Santillana, "The Role of Art in the Scientific Renaissance," in *Critical Problems in the History of Science*, ed. Marshall Clagett (Madison: University of Wisconsin Press, 1959), 33–65; Samuel Edgerton, Jr., *The Heritage of Giotto's Geometry: Art and Science on the Eve of the Scientific Revolution* (Ithaca, N.Y. and London: Cornell University Press, 1991); J. V. Field, *The Invention of Infinity: Mathematics and Art in the Renaissance* (Oxford: Oxford University Press, 1997). Art historians include James S. Ackerman, "The Involvement of Artists in Renaissance Science," in *Science and the Arts in the Renaissance*, ed. John W. Shirley, F. David Hoeniger (Washington, D.C.: Folger Shakespeare Library, 1985), 94–129; idem, "Early Renaissance 'Naturalism'"; Svetlana Alpers, *The Art of Describing: Dutch Art in the Seventeenth Century* (Chicago: University of Chicago Press, 1983); Michael Baxandall, *The Limewood Sculptors of Renaissance Germany* (New Haven, Conn.: Yale University Press, 1980); Thomas DaCosta Kaufmann, *The Mastery of Nature*; Martin Kemp, *The Science of Art* (New Haven, Conn.: Yale University Press, 1990); David Freedberg, *The Power of Images: Studies in the History and Theory of Response* (Chicago: University of Chicago Press, 1989); idem, "Science, Commerce, and Art: Neglected Topics at the Junction of History and Art History," in *Art in History, History in Art: Studies in Seventeenth Century Dutch Culture,* ed. David Freedberg and Jan de Vries (Santa Monica, Calif.: Getty Center for the History of Art and the Humanities,1991); Caroline Jones and Peter Galison, *Picturing Science Producing Art* (New York: Routledge, 1998).

42. "There is a two-way street here between art and natural knowledge. The analogy to the new experimental science suggests certain things about art and artistic practice, and the nature of the established tradition of art suggest a certain cultural receptivity necessary for the acceptance and development of the new science. . . . Didn't northern viewers find it easier to trust to what was presented to their eyes in the lens, because they were accustomed to pictures being a detailed record of the world seen?" Alpers, *The Act*, 25.

43. Kaufmann, *The Mastery of Nature*, and Thomas DaCosta Kaufmann, *Court, City, and Cloister: The Art and Culture of Central Europe 1450-1800* (Chicago: University of Chicago Press, 1995).

44. See the coda to Kemp, *The Science of Art*, esp. 340–341. James Ackerman takes a more developmental view, in which the aims of science and art diverged sometime after Leonardo da Vinci. James Ackerman, "Science and Visual Art," in *Seventeenth Century Science and the Arts,* ed. Hedley Howell Rhys (Princeton, N.J.: Princeton University Press, 1961): 63–90.

45. If we understand art to include other kinds of artisans (as it would have been understood in the early modern period), then there have been numerous studies of the way in which the new science rested on the work of artisans. This view has its origins in early history of science, including the essay by Edgar Zilsel, "The Sociological Roots of Science," *American Journal of Sociology* 47 (1942): 544–562; and the work of Paolo Rossi, particularly *Philosophy, Technology, and the Arts in the Early Modern Era*, trans. Salvator Attanasio (New York: Harper & Row, 1970); as well as Reijer Hooykaas, "The Rise of Modern Science: When and Why?" *British Journal for the History of Science* 20 (1987): 453–473. Arthur Clegg, "Craftsmen and the Origin of Science," *Science and Society* 43 (1979): 186–201, holds a similar view. See also Paolo Rossi, "Hermeticism, Rationality and the Scientific Revolution," in *Reason, Experiment, and Mysticism in the Scientific Revolution*, ed. M. L. Righini Bonelli and William R. Shea (New York: Science History Publications, 1975): 247–273. More recent historians pursuing this approach are James A. Bennett, "The Mechanics' Philosophy and the Mechanical Philosophy," *History of Science* 24 (1986): 1–28; idem, "The Challenge of Practical Mathematics," in *Science, Culture, and Popular Belief in Renaissance Europe*, ed. Stephen Pumfrey, Paolo Rossi, Maurice Slawinski (Manchester: Manchester University Press, 1991), 176–190; William Eamon, in *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture* (Princeton, N.J.: Princeton University Press, 1994); Michael Hunter, *Science and Society in Restoration England* (Cambridge: Cambridge University Press, 1983); Pamela O. Long, "The Contribution of Architectural Writers to a 'Scientific' Outlook in the Fifteenth and Sixteenth Centuries," *Journal of Medieval and Renaissance Studies* 15 (1985): 265–298; and idem, "Power, Patronage, and the Authorship of Ars," *Isis* 88 (1997): 1–41; Bruce T. Moran, "German Prince-Practitioners: Aspects in the Development of Courtly Science, Technology, and Procedures in the Renaissance," *Technology and Culture* 22 (1981): 253–274.

46. Lorraine Daston has warned against invoking a struggle to legitimate oneself by claiming access to nature, but in the case of artisans, their claim to legitimacy or authority on the basis of their knowledge of nature was made over and over again and justified by their ability to produce: to effect works and tangible things rather than words. Lorraine Daston, "The Nature of Nature in Early Modern Europe," *Configurations* 6 (1998): 149–172.

47. Among works arguing that artists were seeking to legitimate themselves and their art, see Joseph L. Koerner, *The Moment of Self-Portraiture in German Renaissance Art* (Chicago: University of Chicago Press, 1993); Victor I. Stoichita, *The Self-Aware Image: An Insight into Early Modern Meta-Painting*, trans. Anne-Marie Glasheen (Cambridge: Cambridge University Press, 1997); Hans Belting and Christiane Kruse, *Die Erfindung des Gemäldes: Das erste Jahrhundert der niederländischen Malerei* (Munich: Hirmer Verlag, 1995). In "Augustan Realities: Nature's Representatives and Their Cultural Resources in the Early Eighteenth Century," in *Realism and Representation: Essays in the Problem of Realism in Relation to Science,*

Literature, and Culture, ed. George Levine (Madison: University of Wisconsin Press, 1993): 279–311, Simon Schaffer argues that marginal scientific practitioners in the eighteenth century "worked hard to make a direct access to nature count and then make it clear that they had such access" (296). Such an observation also applies to practitioners and artisans of all kinds in the sixteenth and seventeenth centuries.

48. Natalie Zemon Davis, *Women on the Margins: Three Seventeenth-Century Lives* (Cambridge, Mass.: Harvard University Press, 1997); Charlotte Jacob-Hanson, *Maria Sibylla Merian, Artist-Naturalist* (New York: Brant Publications, 2000).

49. In addition to Alpers's important book *The Art of Describing*, see Brian Ogilvie, *The Science of Describing: Natural History in the Sixteenth Century* (forthcoming).

50. Baxandall, *Painting and Experience*.

51. John Michael Montias, *Artists and Artisans in Delft: A Socio-Economic Study of the Seventeenth Century* (Princeton, N.J.: Princeton University Press, 1982); idem, *Vermeer and His Milieu: A Web of Social History* (Princeton, N.J.: Princeton University Press, 1989); John Michael Montias, Gilles Aillaud, and Albert Blankert, *Vermeer* (Paris: Hazan, 1986). For an overview, see Michael North, *Art and Commerce in the Dutch Golden Age*, trans. Catherine Hill (New Haven, Conn.: Yale University Press, 1997; German ed. 1992).

52. Reindert Falkenburg, Jan de Jong, Dulcia Meijers, Bart Ramakers, Mariët Westermann, eds., *Kunst voor de Markt, 1500–1700* (Zwolle: Waanders Uitgevers, 2000).

53. Many valuable contributions to this discussion will appear in *The Culture of Exchange: Real and Imagined Markets in the Low Countries, 1500–1800*, ed. Liliane Weissberg (in preparation).

54. Max Weber, *The Protestant Ethic and the Spirit of Capitalism*, trans. Talcott Parsons (New York: Harper Collins, 1930).

55. Robert K. Merton, *Science, Technology and Society in Seventeenth Century England* (Bruges: St. Catherine Press, 1938), 231. In the sections he titled "Science, Technology and Economic Development," Merton explicitly tied the rise of science to the rise of capitalism.

56. Ibid., 238.

57. Similarly, other works of the 1930s and early 1940s that treated the relationship between capitalism and science—such as Boris Hessen, *The Social and Economic Roots of Newton's Principia* (London: Kniga, 1931); Edgar Zilsel, *Die Entstehung des Geniebegriffes; ein Beitrag zur Ideengeschichte der Antike und des Frühkapitalismus* (Tübingen: Mohr, 1926); and Edgar Zilsel, "The Sociological Roots of Science"—did not lead to any significant research in this area, at least not in anglophone scholarship. In the late 1950s and early '60s, Paolo Rossi published what came to be titled in the 1970 English edition *Philosophy, Technology, and the Arts in the Early Modern Era*, which took up many of Zilsel's themes.

58. Michael A. Dennis, "Historiography of Science: An American Perspective," in *Science in the Twentieth Century*, ed. John Krige and Dominique Pestre (Amsterdam: Harwood Academic Publishers, 1997), 1–26, gives a very nuanced evaluation of the effects of the particular circumstances of postwar United States on the growth and character of the profession of the history of science.

59. In this light it is perhaps not surprising to find the degree to which science was separated from material relations, which can be seen in A. R. Hall's "The Scholar and the Craftsman in the Scientific Revolution," in *Critical Problems in the History of Science*, ed. Marshall Clagett (Madison: University of Wisconsin Press, 1959) and, somewhat more surprisingly, in Thomas Kuhn's "Mathematical versus Experimental Traditions in the Development of the Physical Sciences," *The Essential Tension* (Chicago: University of Chicago Press, 1977). In this work, Kuhn even naturalized the difference by claiming that it was "rooted in the nature of the human mind" (64).

60. An example of such an orientation is Antonio Pérez-Ramos's excellent *Francis Bacon's Idea of Science and the Maker's Knowledge Tradition* (Oxford: Clarendon Press, 1988).

61. Francis Bacon, *The Great Instauration*, 1620.

62. It should be noted here that in his forgotten chapters, Merton made the relationship between commerce and science quite clear also, but there is a very significant difference between his story and the new historiography of this question: the number and range of people who are relevant to the story of the scientific revolution have been vastly extended in the new history of science. Merton, like his contemporaries, told the well-known story of the Scientific Revolution, which recounted the lives and ideas of a few scholars and dwelled long and lovingly on England in the last half of the seventeenth century.

63. The centrality of medical practitioners in the scientific revolution is suggested by Harold J. Cook, "The Cutting Edge of a Revolution? Medicine and Natural History Near the Shores of the North Sea," in *Renaissance and Revolution: Humanists, Scholars, Craftsmen, and Natural Philosophers in Early Modern Europe*, ed. J. V. Field and Frank A. J. L. James (Cambridge: Cambridge University Press, 1993), 45–61.

64. See Otto Pächt, "Early Italian Nature Studies," on early herbals and *tacuina sanitatis*. From the Middle Ages, the illustrations in these manuals often showed the herbalist digging up the plants, or in some other way making clear his personal eyewitnessing or handling of the plant, even when the herbs themselves were not rendered realistically.

65. Merton made commerce one of the prime legitimators of science in England, but placed this phenomenon in the late seventeenth century: "The development of scientific societies was not unrelated to this interest in enlisting the scientist in the service of industry, commerce and army. For the rising bourgeoisie, science and technology held out a promise which was not to be ignored; for the scientist-inventor, economic developments introduced or emphasized problems which, if attacked and solved, promised some financial reward and more prestige" (159).

66. Pagden, *European Encounters*.

67. Albert O. Hirschman, *The Passions and the Interests: Political Arguments for Capitalism before Its Triumph* (Princeton, N.J.: Princeton University Press, 1977) was one of the first to notice the prevalence of the discourse about the passions in early modern Europe. Recent interest in the passions has yielded Susan James, *Passion and Action: The Emotions in Seventeenth-Century Philosophy* (Oxford: Clarendon Press, 1997); and Stephen Gaukroger, *The Soft Underbelly of Reason: The Passions in the Seventeenth Century* (New York: Routledge, 1998).

68. Lorraine Daston, "Curiosity in Early Modern Science," *Word and Image* 11, no. 4 (1995): 391–404. See also Lorraine Daston and Katharine Park, *Wonders and the Order of Nature* (New York: Zone, 1999). For one preliminary attempt to write a history of the senses, see J. R. R. Christie, "The Paracelsian Body," in *Paracelsus: The Man and His Reputation, His Ideas, and Their Transformation*, ed. Ole Peter Grell (Leiden: Brill, 1998).

69. Translated and quoted in Parshall, "Imago Contrafacta," 561.

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Part 1

STRUGGLING WITH REALITY

Visualizing Nature and Producing Knowledge

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Splendor in the Grass

The Powers of Nature and Art in the Age of Dürer

LARRY SILVER AND PAMELA H. SMITH

Sheep and oxen, all of them,
Yea, and the beasts of the field;
The fowl of the air, and the fish of the sea;
Whatsoever passeth through the paths of the seas.
O Lord, our Lord,
How glorious is Thy name in all the earth!

—Psalm 8

One of the most striking new images in German art in the era of Albrecht Dürer remains the Virgin Mary situated out of doors. Its combination of natural description and spirituality offers a key to understanding the special yet unarticulated powers associated with nature in early modern Germany. Investigating the new ways in which Dürer and his imitators began depicting nature in the period from 1450 to 1550 can provide an entry point into artisanal attitudes to nature and natural knowledge.

Dürer's Madonna conforms to a late medieval type, associated with the *humus* of the earth, known as the "Madonna of Humility."[1] Late medieval visual tradition also situated Mary in a symbolic enclosed garden, or *hortus conclusus*, of the Song of Songs (4: 12), redolent of her virginity; a notable Rhenish example is the name painting of the Master of the Enclosed Garden (Frankfurt, Staedel).[2] Striking about the images of the Madonna outdoors by Dürer and his contemporaries is the absence of these traditional protective garden walls; these figures sit in wide-open spaces, immersed in expanse rather than confinement.

Dürer's images of the Virgin outdoors on either the ground or a grassy bench begin with his engraving *Madonna with the Mayfly*, ca. 1495 (Meder

Figure 1.1 Albrecht Dürer, *Madonna with a Mayfly*, ca. 1495. Courtesy of the Albertina, Vienna.

42; fig. 1.1), which features a characteristic local landscape, akin to the watercolor settings made in the vicinity of Nuremberg, which Dürer first recorded at around the same time.[5] Yet erupting into this ordinary setting, on the central vertical axis with the Madonna and child in this print, is an extraordinary heavenly epiphany, as God the Father and the dove of the Holy Spirit appear in open clouds directly over Mary, to complete the Trinity with the infant Christ.

In other, slightly later Dürer images of the Madonna outdoors, such as the woodcut *Holy Family with Three Hares* (Meder 212) the same grassy bank recurs, although in front of the extensive, receding landscape setting stands a stone enclosure, reestablishing the tradition of the *hortus conclusus*. Here

the Christ child reads precociously from a holy book while a pair of hovering angels above the Virgin bear her heavenly crown, even as she sits humbly on her grassy bank. The presence of the hares has never been explained, but the inevitable association of this most fertile of animals (especially for a group of them together across the bottom of the print) with fecundity suggests generation as an important aspect here of the holy family, although the conception of Christ is expressly not sexual (or worldly or basely animalistic), as the advanced age of St. Joseph assures. The other most important element in the print is botanical: the several large weedlike plants on the favorable right (*dexter*) side of the Virgin. These plants have never been identified, though both position and size suggest their positive, possibly medicinal properties.[4] Indeed, the shorter foreground plant with fleshy leaves resembles the frequent depiction of a mandrake, a plant whose legendary magical and medicinal (chiefly narcotic or poisonous) properties included a perceived homunculus in its forked root system, making it shriek when pulled from the ground.[5] The presence of this plant beside the holy figures lends a particular charge, related to the conception of Christ, which can also be related to the passage in Genesis 30:14–24, where eating mandrake is expressly connected to divine intervention in the pregnancy of Rachel with Joseph, an Old Testament antitype for Christ: "God hearkened to her and opened her womb. She conceived and bore a son." (30:22–23). This combination of mandrake (and grasses, the significance of which remains to be determined) with the fertility of the hares in the enclosed setting of the Madonna suggests her miraculous virgin birth; at the same time, the affinity between the natural world and the holy figures in this work joins with the explicit link between heaven and earth in the *Madonna with the Mayfly* to suggest a cosmic resonance between sacred and profane, celestial and terrestrial, macrocosm and microcosm.

Most commentators on these images of the Madonna outdoors have assumed that the scene has a foundation in narrative, specifically the story of the Flight into Egypt, when the holy family fled for its own safety from the dangers of Herod's Massacre of the Innocents. Yet Dürer never seems to try to represent exotic scenery as the landscape background of these scenes, in striking contrast to his later *Flight into Egypt* woodcut from the *Life of the Virgin* cycle (ca. 1503–04; Meder 201). In that image, the left-to-right movement of the figures across the setting shows their flight, and two distinctly exotic non-European trees, palm tree and "dragon tree," mark the location as "foreign," even close to the lost paradise of Eden.[6] Moreover, the presence of the hovering angels with the crown of Mary in the woodcut offers a hieratic theophany through symbolic royal synecdoche, as if in distillation of the actual vision manifested in the *Mayfly* engraving. Such scenes are not narratives, but instead provide assertions about the nature of the holy figures,

especially the incarnate figure of Christ, poised between the world and the divine order of the cosmos.

As if to confirm this mediating role of Christ and the symbolic presentation of theological concepts, Dürer next (ca. 1497–98) produced a more mature engraving, the *Madonna with the Monkey* (Meder 30). Scholars agree in reading this animal as a symbolic image of human sin, the error of old Adam, enchained and redeemed by the presence of Christ.[7] This fettered monkey contrasts with the freedom of the bird in Christ's own hand; wings associate the creature with both angels and the human soul, and the creature is actually nourished by the hand of the child.[8] On the grassy bench to the (favorable) right of the Virgin, a prominent foreground plant, a "star of Bethlehem," surely signals the location and refers unobtrusively to the event of the Nativity.[9] In this print, no structure of enclosure remains to isolate a garden from the wider landscape; in contrast, the background landscape derives closely from a watercolor study from the vicinity of Nuremberg, the *'Weiherhaus'* (London, British Museum, W. 115).[10] This Madonna and child image, which completely eliminates St. Joseph and any suggestion of the holy family, could not be misconstrued as a narrative moment.

Climaxing these suggestions that the natural world responds to the character and virtues of the holy figures, Dürer produced a colored ink drawing in 1503, *Madonna with a Multitude of Animals* (Vienna, Albertina; fig. 1.2).[11] This drawing, a prized cornerstone of the old master collection of Emperor Rudolf II at the end of the sixteenth century, was copied in both an engraving (in the same orientation as the original) by Aegidius Sadeler as well as a painting by Jan Brueghel (1604; Rome, Palazzo Doria).[12] This image does contain background narratives, chiefly the Annunciation to the Shepherds by the angel, as well as the figure of St. Joseph standing at a small distance behind the central Madonna and child. Yet fundamentally it is neither a Nativity nor a narrative scene but rather another image of resonance between these holy figures and the rich diversity of life in nature, exemplified by the multitude of animals that surround Mary and Christ. Again the epiphany of heaven finds expression not only in the form of the hovering angel but also in the form of the star of Bethlehem directly above the holy figures (occupying the spot of God and the dove in the *Mayfly* engraving).[13] If the size of the main figures as well as their seated or enthroned posture on the inevitable grassy bank suggests a hierarchy (with Joseph reduced in size and confined to the middle distance and extreme right), it is noteworthy that plants and animals fill the immediate foreground, which is marked off as the holiest space by another "garden" wall, albeit one only as high as the level of the grassy bench.

Continuity with the *Madonna with the Monkey* can be seen in the two holy figures, their postures and gestures, though here Christ gestures off in the

Figure 1.2 Albrecht Dürer, *Madonna with a Multitude of Animals*, 1503, Albertina, Vienna. Courtesy of Art Resource, New York.

direction of St. Joseph and does not attend directly to an animal like the bird in his hand in the engraving. Mary is now veiled, and her enfolding mantle becomes more noticeable on both sides of her body, evoking the protective *Schutzmantel* of standing Virgin of Mercy figures in German art of the period, which often serves as an image of prophylaxis against plague.[14] Here her sheltering role is focused on the Christ child alone rather than all of

humanity, but in effect her benign protection serves to extend grace to the world, including the animals and plants. In this later redaction the fox at the feet of Mary, bound with collar and leash, continues the symbolism of the *Madonna with the Monkey* of restraint for humanity's animal sinfulness.[15] The parrot, the bird of intelligence and speech, was associated with Mary as the Throne of Wisdom and traditionally equated with the Annunciation, even credited with saying "ave."[16] Surrounding the Virgin, as if emanating from her person, are flowers (rose/peony, iris) and fruits (strawberry) that traditionally embody her virtues.[17] Moreover, the hollyhocks beside the owl offer a positive antidote to the evil influences of that bird.[18]

Dürer's imagery of the Madonna outdoors, using animals and other natural items to demonstrate the resonance between holy figures and God's creatures, continued in the works of younger imitators. Shortly after the turn of the sixteenth century, Lucas Cranach painted a 1504 image of the holy family in a forest, which is usually designated as a *Rest on the Flight into Egypt* (Berlin) and was followed in turn by a 1509 woodcut of the same subject (fig. 1.3).[19] This work is not explicitly a narrative either, though there is more suggestion of movement. Here the holy figures, including St. Joseph, pause within a landscape setting of forest or mountain glade in order to rest upon the ground. The forest setting serves principally as a retreat and haven for the holy figures instead of being their visible domain (suitable for showing the Madonna enthroned, even if on her grassy bank). More important, the suggestion of narrative events is underscored by the presence of miracles, such as the drawing of water by a cluster of small angels. In all likelihood, the textual source for this event is an apocryphal gospel, Pseudo–Matthew 20, where the child Jesus bids a palm tree to bend low and offer its fruit at the feet of Mary, while a spring emerges from its roots. In the Cranach woodcut the tree is bent low by angelic agents, and its spring lies below. Symbolic plants in the glade at the foot of Mary suggest the influential presence of her holiness: strawberries, fruits of paradise; cowslip, the plant known in German as "heaven's key" (*Himmelschlüssel*); columbine, traditional Marian flower of sorrow, showing the canonical seven sorrows in its floral shape as well as the mood of melancholy in its purple color.[20] Beside them a thorn serves as contrast and as an anticipation of Christ's Passion. The finch, associated with thorns, is carried (rather roughly) by one of the angels; this bird usually symbolizes Christ's triumph over the Passion in the form of the Resurrection.[21] The presence of this bird in the Cranach scenes could refer to another apocryphal text (Gospel of Thomas), in which the child Jesus (age five, according to the text) fashioned birds out of clay (twelve sparrows) on the Sabbath; these new creatures took flight while he played with many other children.[22] In short, the very landscape in Cranach's *Rest on the Flight into Egypt* becomes energized by their divine powers, visibly denoted by the

Figure 1.3 Lucas Cranach, *Rest on the Flight into Egypt*, 1509.

plethora of angels of various sizes and shapes (possibly of different kinds; there were nine orders of angels, according to medieval theology). Moreover, the site manifests the glory of the holy figures through the presence of meaningful plants and animals, already the case with Dürer's earlier images of the Madonna outdoors.

Related to the model of Cranach's images of the holy family in a forest retreat, a large panel by Altdorfer of *Saints John the Evangelist and John the Baptist* (Regensburg, Stadtmuseum; fig. 1.4) features the two holy men in their roles as hermits, the Baptist on the right in his role as the "voice crying in the wilderness," the Evangelist on the left as the author of the Book of Revelation during his sojourn on the island of Patmos.[23] Here, too, as Behling pointed out,[24] the wilderness is crowded with portraitlike representations of actual plants, highlighted next to the Baptist at right by the large and magnificent mullein plant, known more colloquially for its shape in German as "King's candle" (*Königskerze*; *candela* in Latin). This summer-blooming plant was understood to be a powerful medicament, tied to powerful celestial forces, which would accord with the visionary epiphanies of these two isolated holy men. Moreover, the plant was a prominent decoration associated with the feast day of the birth of John the Baptist, June 24, itself a marker of solstice and a popular folk festival often celebrated with bonfires.[25] Two other prominent plants in the center foreground of the *Two Saints John* (fig. 1.4) are sage and henbane (or "deadly nightshade"), the former a healing herb and digestive, the latter a poison shown just in front of the Lamb of God). One can recall in this context that the normal attribute of John the Evangelist is a chalice with a snake, because of a legend that the saint survived an attempt by a pagan priest to poison him, so the presence of sage and henbane in front of St. John are appropriate opposites, a deadly threat and its natural antidote. Animals, tiny but significant, also populate the Altdorfer image beside the Evangelist: a snail and a butterfly. Traditionally both refer symbolically to Christ's Resurrection (according to medieval beliefs, snails remained buried in the earth for the three coldest months of winter and then emerged as the weather warmed up).[26]

It should be noted that the outlook associating tiny animals with great, even cosmic significance endured through the course of the sixteenth century. This view is particularly vivid in the presentation of insects within the overall luxury miniatures by Georg Hoefnagel illustrating the animal world of the *Four Elements* (Washington, National Gallery of Art), a work produced for Emperor Rudolf II around the beginning of the last quarter of the sixteenth century.[27] As Hendrix's fine study makes clear, insects dominate the volume on the element Fire (*Ignis*), exemplifying the concept of the microcosm, or *multum in parvo*; moreover, the text atop folio 1 of *Ignis* testifies to the significance of connections between earth's creatures and their

Figure 1.4 Albrecht Altdorfer, *The Two Saints John*, 1515. Courtesy of the Stadtmuseum, Regensburg.

heavenly creator: "Of all the miracles made by man, a greater miracle is man. Of all visible miracles, the greatest is the world. Of those invisible, God. If we see that the world exists, we believe God exists."[28]

When Altdorfer painted his 1510 *Rest on the Flight into Egypt* (Berlin; fig. 8), he underscored the visible manifestation of holiness in the landscape through magical transformations.[29] This painting doubtless had strong personal significance for the painter, since he not only signed it but also dedicated it prayerfully with a dedication to the Virgin on the base of the miraculous fountain: *A[l]b[er]tus Altorffer [p]ictor Ratis/ponen[sis] In salutem a[nima]e hoc tibi/munus diva maria sacravit/ corde fideli: 1510* (Albrecht Altdorfer, painter of Regensburg, dedicated this gift to you, St. Mary, with faithful heart in (hopes of) the health of his soul).

At first glance, the Altdorfer *Rest on the Flight* (fig 1.5) offers another instance of the theme of the holy family beside a riverside landscape akin to the Dürer engravings, although one can perhaps make an interpretive equation between the fortified gateway in the background town and the traditional metaphor of the Virgin as both the "portal of Heaven" (*porta coeli*) or the "tower of David" (*turris David*). Again Mary is seated upon a modest,

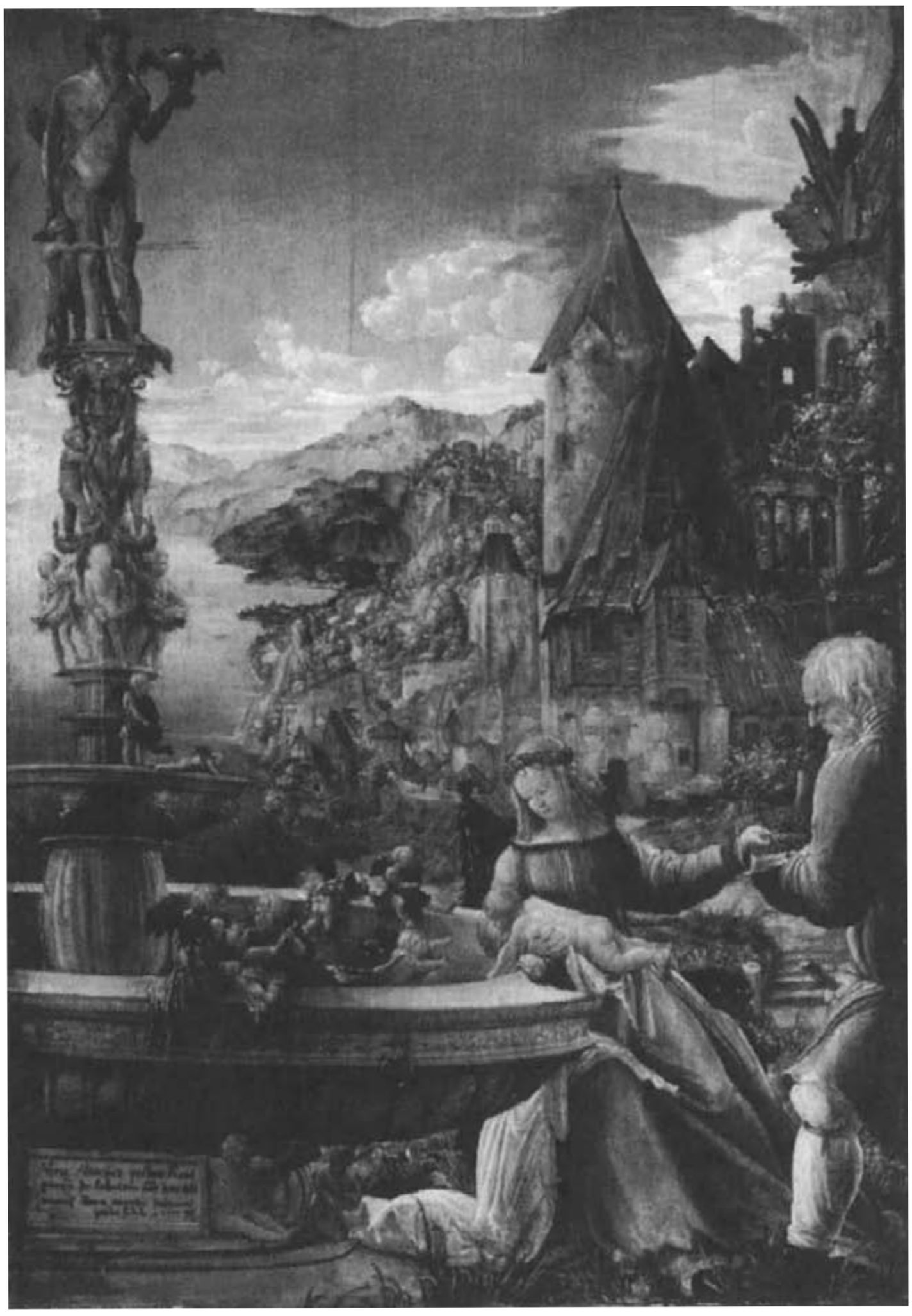

Figure 1.5
Albrecht Altdorfer, *Rest on the Flight to Egypt*, 1510.
Courtesy of Staatliche Museen Preussischer Kulturbesitz, Gemäldegalerie, Dahlem, Berlin.

draped "throne" before or upon a grassy bank. She takes cherries, another fruit of heaven,[30] from the aged Joseph. But the striking anomaly within Altdorfer's vision of this setting is an incongruous, dominant foreground fountain along the left side.[31] This fountain surely evokes recollections — within a worldly landscape — of paradise as well as traditional symbolism of Mary-as-fountain, something that Altdorfer reinforced shortly afterward with a woodcut, *Holy Family by a Fountain* (ca. 1512/15, W. 83).[32] What makes the fountain in the painting so unusual is its figure at the top: a pagan statue on a plinth. But this is not a threatening paganism, for in the lower basin another lively cluster of playful, cherubic angels climb, swim, and make music, while the Christ child, unswaddled and naked, leans from Mary's lap over to the basin to join their play. Moreover, it is at the foot of this astonishing fountain that Altdorfer appended his prayerful Latin inscription, monogram, and date, as if it were his own pictorial "gift" (*munus*) to the Virgin.

The pagan god atop the fountain must be Apollo. Although bearded and muscular, like standard representations of Hercules, he wears a crown of laurel, sacred to Apollo. His quiver of arrows is an ambiguous attribute; on the one hand, Apollo was a renowned archer, who slew Python (perhaps an appropriate serpent analogue to the Virgin and Christ, conquerors of Satan) as well as the children of vainglorious Niobe. Yet Hercules, too, was a noted archer, who slew the Stymphalian Birds with arrows among his celebrated twelve labors.[33] The main figure is accompanied by a blindfolded Cupid, who holds a bow with two arrows, one sharp and the other blunt. This secures the Apollo identification (as well as the divine nature of the muscular bearded figure), because the two contrasting arrows of Cupid refer to the respective shafts that were shot into Apollo (sharp) and Daphne (blunt), after the Python incident, as recounted by Ovid (*Metamorphoses* I, 446–52). Thus the emphatic presence atop the fountain of Apollo, with his pure (and unrequited) love for Daphne, and Cupid suggest pagan analogies, or even typologies, for the divine love principle (including the fruit of cherries) of the Christian holy family alongside that fountain. At the same time, the presence of the fountain itself attests to the extraordinary powers of the holy figures in an otherwise ordinary landscape, akin to the exploits of the Christ child as recounted in the apocryphal pseudo-Gospels.

Still more mysterious on the fountain is the item held by the Apollo figure. It appears to be an egg with wings and ducklike feet and its own laurel crown on top. A similar combination of egglike cup with wings and duck feet (surmounted, however, by a lion rather than a laurel) forms the subject of an emblematic Dürer drawing of 1513 (Berlin; W. 703), along with the inscribed motto *Fortes Fortuna Juvit* (Fortune favors the strong) (fig. 1.6).[34] This combination of lion with egg recalls the presence of lions' heads on the fountain ornament by Altdorfer in both the Berlin painting and the woodcut, which suggests some overlap of meaning with the Dürer drawing. Lions are often associated with Christ not only by virtue of being considered the king of beasts, but also because bestiary lore claimed that lion cubs were born dead but raised to life after three days when breathed upon by their sire.[35]

As Eisler and Hartlaub both observe, Dürer also paired lions with the figure of Apollo (shown with a laurel crown and a bow but beardless) in an early drawing made during his first stay in Venice, ca. 1495 (Vienna, Albertina; W. 87). In that drawing, Dürer also shows a turbaned "oriental" or Turkish alchemist figure holding a skull as a book sits at his feet. On a small tripod between the god and the savant sits a smoking globe, labeled "lutus," that is the *lutum sapientiae*, the "sealing-wax of wisdom" in alchemy.[36] Indeed, the direct association of alchemy with an exotic, Levantine "magus" strongly suggests that this knowledge is both ancient and occult, a frequent belief of early modern natural philosophers.[37] Both its shape and association with Apollo

Figure 1.6 Albrecht Dürer, *Drawing of an Egg Cup with Wings*. Courtesy of Kupferstichkabinett, Berlin.

suggest that this globe should be thought of as the analogue to what Altdorfer produced as an egg on his fountain summit.

Alchemical themes and images were broadly disseminated in manuscript and in print by the sixteenth century, and both Dürer and Altdorfer could *well* have been familiar with alchemy from Latin or vernacular sources. Historians have debated the esoteric and alchemical meaning of these artists' imagery,[38] but whatever the artists' knowledge of the esoteric aspects of alchemy, artisanal and alchemical practices overlapped.[39] In his 1390 manual for painters, Cennino Cennini described certain pigments as being produced

by "*alchemia,*"[40] and Dürer had perhaps learned metallurgical techniques in the workshop of his father, a goldsmith. In any case, alchemy was more than a set of theories or techniques. Throughout the early modern period, alchemy seems to have formed a language for artisans who wanted to articulate their processes of working, as well as for scholars, who were trying to understand how artisans created things from matter. The fact that artisans worked with their hands and learned by apprenticeship separated them socially and intellectually from most scholars, who regarded the mechanical arts as existing across a deep divide. This began to change in the sixteenth century as humanists, such as Petrus Ramus (1515–72) and Juan Luis Vives (1492–1540), exhorted their fellow scholars not to "be ashamed to enter into shops and factories, and to ask questions from craftsmen, and to get to know about the details of their work."[41] The late fifteenth and early sixteenth centuries were crucial for the development of a new relationship between scholars and craftspeople.[42] Because alchemy was one of a few disciplines in which people worked both with texts and with their hands, scholars and craftsmen alike had practiced it since the Middle Ages, and it played a central role in articulating this new relationship.[43] Furthermore, alchemy and artisanry possessed a common essence: the ennobling of matter through manual work. Although today we associate alchemy mainly with the transmutation of base metals into gold, in the early modern period it was indistinguishable from what we would today call metallurgy or chemistry, or even organic chemistry, for alchemists sought the composition of the vital principle through which they could effect transformations of matter of all kinds, as well as heal disease and prolong life. It thus had much in common with medicine as well as with artisanship. Indeed, on a cosmic scale, alchemy was the epitome of all artisanal activity, for it redeemed matter, just as the practice of the arts (and medicine) did. All such activities resulted from the Fall and helped to redeem humankind after the expulsion from Eden.

It is thus not surprising that we would find an interest in alchemy in Dürer's drawings and Altdorfer's paintings, and it is possible to elaborate their alchemical allusions in terms of alchemical theory. For example, their use of Apollo, the classical sun god, points to the privileged position in alchemical thought of solar imagery, which was identified with the metal gold and with a generative male principle, or fiery spirit, that joined with matter.[44] Sulfur, one of the two principles of alchemical transmutation, by which base metals were ennobled, was identified with the sun, gold, and nobility.

Moreover, eggs, placed as central objects by both Dürer and Altdorfer, held special significance in alchemical precepts as the model for the secret, enclosed generation of life out of inanimate matter.[45] The "philosophical egg" of alchemical theory could symbolize a model of the cosmos as well as denote the source of the philosophers' stone, the material by which alchemists trans-

muted base metals into gold and silver. In addition, a laboratory vessel having a rounded shape and short neck, known as an "egg," or Hermetic vase, was supposed to be particularly effective in generating the philosophers' stone. When artists depicted the alchemical process by which the philosophers' stone was produced, it was often within such egglike vessels. The most fully developed of such depictions, Salomon Trismosin's alchemical *florilegium*, *Splendor Solis*, produced in Nuremberg in the 1530s, possibly by Albrecht Glockendon or his workshop, shows the progression from the black putrefying material in such a vessel, through the multicolored "tail of the peacock," to the final stage of the transmutation, when the mass in the "egg" turns red, then is suddenly transformed into gold.

One of the illustrations in the *Splendor Solis* displays a hermaphrodite holding an egg in one hand and, in the other, the cosmos, symbolized by the four elements of earth, water, air, and fire. The egg signifies the beginning of all things, out of which the entire cosmos develops.[46] The figure of the hermaphrodite represents the dual principles, sulfur and mercury, involved in alchemical transmutation, which combine to form a unity. Alchemical writers since at least the thirteenth century regarded sulfur and mercury as the primary components of all metals, and they continued to do so well into the seventeenth century.[47] While sulfur and mercury had ordinary forms that could be found in nature and handled by alchemists, in alchemical theory they were understood as principles. Sulfur was viewed as the hot, fiery, male principle, representing the qualities of fire and air and giving metals their combustibility.[48] It combined with the wet, cold, female principle of mercury, combining the properties of earth and water. Alchemical writers identified mercury as the ingredient in metals that gave them their "metallic" qualities, because of its silvery shininess and the fact that it is liquid at room temperature, analogous to the liquidity of metals when heated. In addition, mercury forms amalgams, or alloys, with other metals, particularly gold and silver, in such a way that it is difficult to distinguish the alloy from the pure, noble metal. Mercury also possesses a solid state, a silvery, fluid state, and becomes a volatile spirit when heated. It thus appeared to alchemical writers capable of uniting the qualities of matter and spirit, or fixing the volatile, a common goal of alchemists.[49] Because of its unique qualities, alchemical authors believed mercury played a central part in transmutation, and in the late thirteenth century some alchemists were led to reduce the metallic principles to mercury alone. By the sixteenth century, however, when the *Splendor Solis* was illustrated, the two-principle theory had once again become accepted by most alchemical writers, although the two theories continued to coexist.[50] The "alchemical wedding" of mercury, the female principle, with sulfur, the male principle, resulted in an offspring, the mercury of the philosophers, the main ingredient in the philosophers' stone.

Figure 1.7 "Mercury of the Philosophers" from *Turba philosophorum*, sixteenth century. Ms. lat. 7171, fol. 16. Courtesy of Bibliothèque Nationale, Paris.

A sixteenth-century illustration in a manuscript version of the *Turba philosophorum* shows a naked female figure crowned with a phoenix, standing on the sun and the moon, wings extending to her feet (fig. 1.7). In the hands of this "Mercurius genetrix" are representations of the moon and a chalice out of which shoot flames, perhaps conflating sun, Apollo, and Christ (by reference to the chalice of the eucharist). The verse above this figure reads, "Here is born Sun and Moon's child/ the equal of which no one on

earth can find/ but in the world it's nevertheless well known/ it's called Mercurius philosophorum."[51]

A seventeenth-century engraving shows the marriage of Sol (sulfur) and Luna (mercury), from which issues the mercury of the philosophers in a philosophical egg (fig. 1.8). The flowers springing from the neck of the "egg" denote the generative qualities of the philosophers' mercury that led the eleventh-century alchemical author Rhazes, to call it the "water of life." One of the most famous of all alchemical illustrations, the green lion devouring the sun, out of which runs red blood, signified a similar process. It stood for the process of raw antimony ore drawing in the universal generative spirit to produce a vivified mercury, the vital character of which was denoted by the red blood. This living mercury could dissolve and then revivify gold to make it grow and multiply. Such a substance was the common goal of alchemists from Rhazes to Newton.[52]

The fountain in Altdorfer's painting also runs with the "water of life." While the recurring motif in art of the Fountain of Life clearly had a primarily spiritual dimension, ultimately deriving from the source of waters and flowing rivers described in the Garden of Eden (Genesis 2), it could also be understood in an entirely material way: alchemical theory posited a vivifying principle concentrated in the philosophical mercury but also disseminated throughout nature. It fell with the rain and penetrated the earth with the sun's rays, causing all things to grow and flourish. This view was no doubt reinforced by interest in Neoplatonism in the fifteenth and sixteenth centuries, but the concept of a universal spirit already existed in medieval alchemy and popular pantheism.[53] Thus artists like Leonardo da Vinci wrote of a "spirit of growth" that permeated all of nature.[54] Even artistic creativity itself could be understood as a fluid dispensed by the heavens; artist-author Karel van Mander repeatedly characterized artistic talent as a fluid endowed by *natura generans*.[55]

Elements of Altdorfer's *Rest on the Flight* and Dürer's works can thus be read as referring to components of alchemical theory, but they also point to a more general understanding of nature and function as a means for these artists to make claims about their understanding of nature and nature's processes. One such claim that linked artists and alchemists was their common assertion of "mirroring nature" in their work.[56] From the beginnings of Flemish naturalism the painters' efforts to render precise and detailed representations of nature or of reality were viewed by their contemporaries as a striving after exact replication, not just of nature as it appears to the human eye, but also of nature as the source of generation and production, comprising a kind of double imitation of nature. In 1449, Cyriacus of Ancona described a Flemish painting (probably by Rogier van der Weyden) in similar terms:

Figure 1.8 Johann Daniel Mylius, "Coitus" from *Anatomiae auri sive tyrocinium medico-chymicum*, 1628. Courtesy of the University of Wisconsin, Madison.

> multicolored soldier's cloaks, garments prodigiously enhanced by purple and gold, blooming meadows, flowers, trees, leafy and shady hills, ornate halls and porticoes, gold really resembling gold, pearls, precious stones, and everything else you would think to have been produced, not by the artifice of human hands but by all-bearing nature herself.[57]

"All-bearing nature" was regarded as prolific and copious, a creative force that might be imitated by art. Although the idea of art imitating nature or Creation (*ars imitatur naturam*) went back to antiquity,[58] it could mean more than just producing a mirrorlike image of created nature. *Imitating* nature could mean knowing not just how to mirror nature but could also mean imitating (or reproducing or harnessing) the creative power of nature herself.

The Madonnas in Dürer's prints and Altdorfer's paintings can be viewed not only as alluding to the Fountain of Life but also as signifying the mirror of God (as Jan van Eyck adorns the Virgin in heaven in his Ghent Altarpiece with a passage from the Book of Wisdom, reading, "She is more beautiful than the sun and all the order of stars . . . a spotless mirror of God.").[59] The natural surroundings in which these two artists place Mary also alluded to God, for created nature was also seen as the *speculum dei*. But for Dürer, Nature was also a source of certainty and creativity. In his late treatises on perspective (1525) and human proportion (1528), he stated that certainty lay in nature, and that this certainty was expressed through naturalistic representation:

> But life in nature manifests the truth of these things. Therefore observe it diligently, go by it and do not depart from nature arbitrarily, imagining to find the better by thyself, for thou wouldst be misled. For verily art [i.e., *Kunst*, or theoretical knowledge, as opposed to *Brauch*, or simple practice] is imbedded in nature; he who can extract it has it.[60]

Certain knowledge for Dürer lay not in theory, as scholars commonly held, but rather in nature itself, and his naturalism made clear this primacy of nature as a source of knowledge.

Making this same point, Dürer's contemporary, Paracelsus, also articulated an artisanal mode of cognition and a vernacular epistemology. In his written works, he constantly held up artisans and their knowledge of the material with which they work as models for gaining natural knowledge and for creating effects. Alchemy was both the framework for his entire philosophy and the exemplum for all human arts. For Paracelsus, knowledge of nature was gained not through a process of reasoning, but rather by a union of the divine powers of mind and of the entire body with the divine spirit in matter. This he called "experience." In explaining this concept he drew upon

the ancient terminology of theory and experience, but he inverted the traditional understanding of these terms in a remarkable way. In the schema that organized the pursuit of knowledge from Aristotle up through the sixteenth century, theory (based on geometric demonstration and syllogistic logic) was regarded as the sole source of certain knowledge, while experience was viewed as knowledge of particulars that could never be certain. Paracelsus inverted this relationship. He defined *scientia*, or certain knowledge, as the divine power in natural things, which the physician must "overhear" and with which he must achieve bodily union in order to gain knowledge of natural materials out of which to make medicaments.[61] Thus for Paracelsus certain knowledge was embedded in nature, while experience was the process by which the physician/natural philosopher united with nature and learned this science. "*Scientia* is inherent in a thing. . . . For instance, the pear tree has *scientia* in itself, and we who see its works have *experientia* of its *scientia*. . . . Thus in this book, I show the way *scientia* enters into you."[62] This is an extraordinary inversion of the concepts of theory and practice, one that Paracelsus derived from artisans. In the late fifteenth and early sixteenth centuries, artisans were experts on the processes and transformations of nature, and individuals who wished to know (and take possession of) nature looked to art as the medium through which to accomplish this. This was true not only for physicians and scholars like Paracelsus but also for princes and city governors, who came to regard artisans as holding the key to unlocking the powers of nature.

Naturalism in artisanal work gained momentum in the North throughout the sixteenth century, as did the image of an artist as privileged interpreter of nature. Dürer's example, extended by the next generation of German artists, produced an extreme form of imitating nature in the technique of actual casting from life. A master goldsmith from Nuremberg, Wenzel Jamnitzer (1508–85), was celebrated for this technique (fig. 1.9).[63] One of Jamnitzer's most famous extant pieces is the Merkel Centerpiece of 1549 (fig. 1.10). It features the artist's specialty: grasses and flowers, cast from life, springing from an egglike vessel at the top, while around the base, reptiles, also cast from life, creep forth from the earth. The central female figure represents Mother Earth, and the whole piece symbolizes the fertility and generative powers of nature. It even bears an inscription, "I am the Earth, mother of all things, beladen with the precious burden of the fruits which are produced from myself."[64] Jamnitzer clearly meant to display his own powers of creation in this work as well as his ability to imitate nature, not only by producing an absolute likeness of nature but by harnessing the processes of metallurgy (alchemy) to create this very representation.

Paracelsus's work also gives insight into the way that nature had, for an artisan, an immediacy and primacy: nature itself, not words about nature,

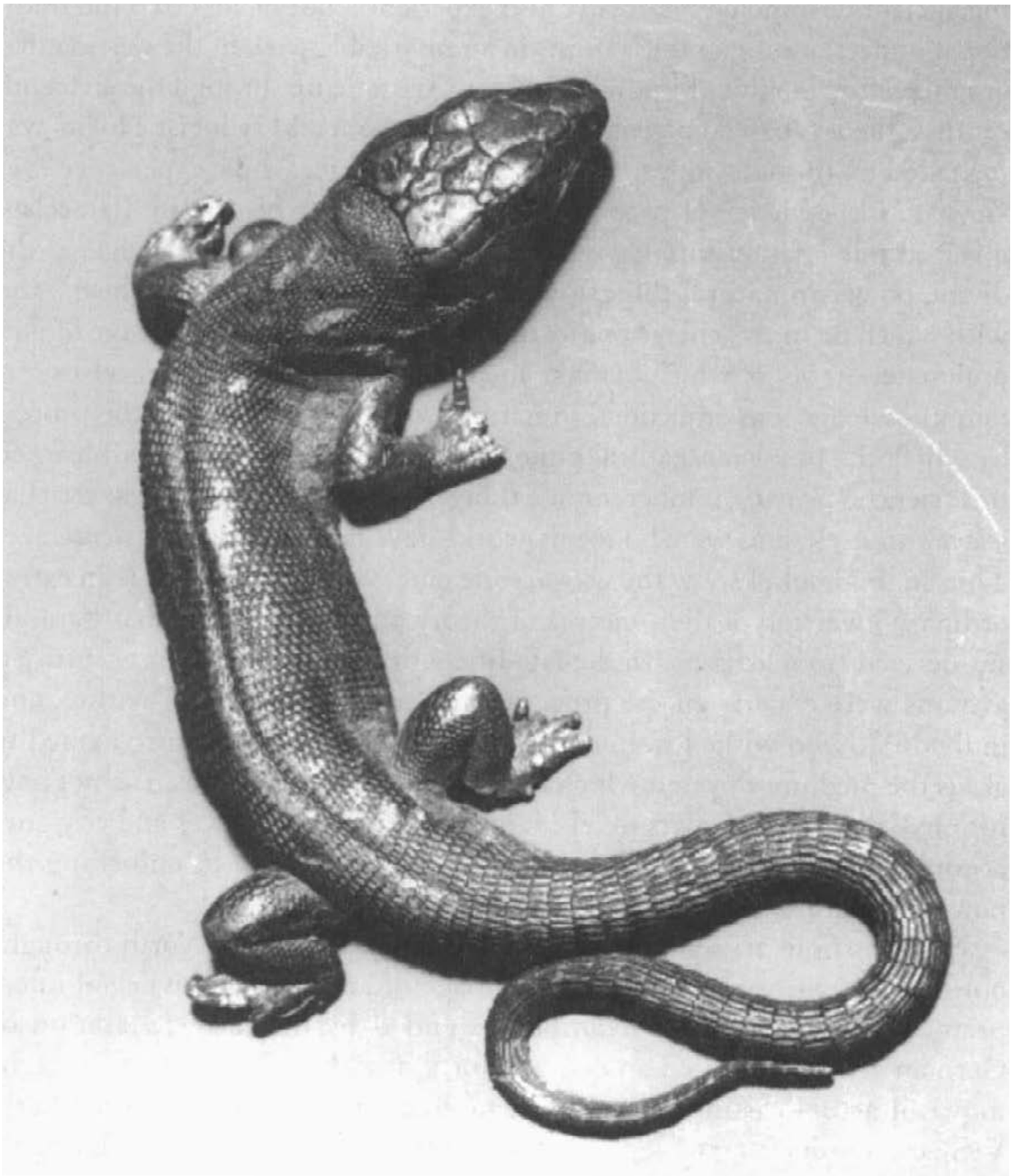

Figure 1.9 Wenzel Jamnitzer, *Lizard*, life cast. Courtesy of Staatliche Museen Preussischer Kulturbesitz, Kunstgewerbemuseum, Berlin.

was the certain *scientia*, which the craftsman got to know through individual *bodily* struggle with matter. This awareness emerges from Paracelsus's idea about a bodily union between the natural philosopher and his object of study,[65] as well as in his statement that the creative power of humans resembled God's but lay in the human body rather than in the Word. What God creates through the word, Paracelsus wrote, a human being creates "with his body and his instruments [senses]."[66]

Figure 1.10 Wenzel Jamnitzer, *Merkel Centerpiece*, 1549. Courtesy of the Rijksmuseum, Amsterdam.

The bodily aspect of artisanal interaction with nature emerges with particular clarity in the work of the ceramicist Bernard Palissy (ca. 1510–90) and his 1580 account of his discovery of white glaze. His book as a whole discusses processes of generation, growth, and change, and is cast as a dialogue in which Theory attempts to pry out of Practice the secret of his enamel-making.[67] Rather than simply giving a recipe to Theory, however, Practice recounts Palissy's harrowing search for the white glaze, and this account is remarkable for its Paracelsian type of experience–Palissy's body and his home are consumed to form a unity with the materials he works. In the end, his labor redeems him and his household. His ceramic amphibians, fish, and reptiles show the realist products, also molded from life itself, of that experience (fig. 1.11).

A related phenomenon recurs in the account by Benvenuto Cellini (1500–71) of the process of casting his statue *Perseus Beheading Medusa*: his body is wasted by fever and illness, the roof of his house catches fire, he attempts to bring the "corpse" of the metal back to life by throwing all his pewter utensils into the molten mass. While his body and his house are consumed, he finally falls to his knees in prayer.[68] Contemporaries, including the painter Bronzino, saw the realistic blood spouting from the head and torso of Medusa as lifelike, while for Cellini this form mimicked the vivifying force that had sent the life coursing back through both the dead metal as well as his own veins.

By the late sixteenth century, Palissy and Cellini were themselves responding to the evolution of the tradition of the artisan as an interpreter of nature that had begun in the work and writings of figures like Dürer and Leonardo, but their view of the functions and processes of nature shows continuity with the earlier period. Dürer, too, had used similar body language to recount his own process of creation. He wrote that in the process of looking, the painter develops his own *Augenmass* (measure or sense of proportion) in his eyes and that by much *Ahmachen* (or reproducing nature from life),[69] he will fill his mind full, and thus accumulate a "secret treasure of the heart," from which he can pour forth in his work, what he "has gathered in from the outside for a long time." For Dürer, the artist was "inwardly full of figures" that he poured out in new inventions, still part of his "direct and faithful representation of a natural object."[70] This bodily experience of the particulars of nature resulted for the artist in knowledge of matter and its transformations, which proved itself through his creation of "effects," or works of art.[71]

As the example of Cellini suggests, the concept of bodily knowledge in the creative process also implicates the bodily labor of the artist's workshop, including the use of body fluids (saliva, urine, blood) along with the natural chemicals of painting pigments, clays, stones, and metals. Artists, like other artisans, were engaged in bodily struggle with and against matter itself, and

Figure 1.11 Attributed to Bernard Palissy, *Oval Plate.* Courtesy of The J. Paul Getty Museum, Los Angeles.

that matter was not dead, but alive, capable of acting in idiosyncratic fashions, which artisans must come to know–and master–through experience.[72]

One of the central components of alchemical theory was the concept that all generation occurred through a process of putrefaction, that is, decay and regeneration. In putrefaction, particular forms of life appeared first: "serpents, toads, frogs, salamanders, spiders, bees, ants, and many worms," according to the formulation of Paracelsus.[73] The reptiles cast from life in the works of both Jamnitzer and Palissy can thus be seen in a new light, as can Martin Schongauer's engraving *Flight into Egypt*, in which lizards or salamanders creep up the trunk of the Tree of Life.[74] Salamanders were believed to be capable of withstanding fire, and thus were a symbol of generation through putrefaction.[75] In alchemical theory, the salamander could also denote sulfur, the hot, fiery, male principle. A return to the creeping creatures that permeate Dürer's *Madonna with a Multitude of Animals* could suggest that these insects and amphibians, too, could signal the beginning of

new life out of the putrefied matter of the old, all under the order and guidance of the divine.

While Altdorfer's *Rest on the Flight into Egypt* does not contain insects, lizards, or salamanders, the winged phoenix egg in Apollo's hand signifies the very same process of regeneration through destruction and putrefaction, for the phoenix, like the salamander, emerges resurrected out of fire.[76] Like Jamnitzer's Merkel Centerpiece, Altdorfer's votive picture appears to have three overlapping themes: the correspondence between spiritual and natural powers, the transformative power of nature, and the place of art in the great work of spiritual and material redemption. Transformation itself is indicated by the arrows in Cupid's hands, those same arrows that eventually caused Daphne to be transformed into a tree. Altdorfer points to the transformational powers of nature in his allusion to the alchemical theory in which Apollo could be seen as sulfur, Mary as mercury, and the fountain as the water of life, the generative principle of nature.

At the same time, Mary, mirror of God and fountain of life,[77] is the vehicle of the macrocosmic transmutation of the world, the process of redemption set in motion by Christ's birth, life, and death. In microcosm, the individual artisan replicates these processes of transformation and redemption. By giving over his painting to the Virgin, Altdorfer alludes to the role that the practice of his art plays in redeeming the "health of his soul." He employs the knowledge of nature, gained by a bodily experience of nature itself, to imitate nature's creative processes and to transform natural materials into a work of art. The powers of nature—inextricably intertwined with divine power—are the wellspring of his own artistic creativity, and the painting as a whole conveys the message that, as an artisan, he is both a knower and a redeemer of matter.

Notes

1. Millard Meiss, *Painting in Florence and Siena after the Black Death* (New York: Harper and Row, 1964), 132–156; H. W. van Os, *Marias Demut und Verherrlichung in der sienesischen Malerei 1300-1450* (The Hague: Ministerie Van Cultuur, Recreatie en Maat Schappelijk, Werk, Staatsuitgeverij, 1969), 77–142. While the prototype images of the "Madonna of Humility" stem from the art of Trecento Siena, this concept spread widely throughout Europe over the course of the century and was widely taken up, for example by Flemish painter Robert Campin. On Campin, see Erwin Panofsky, *Early Netherlandish Painting* (Cambridge, Mass.: Harvard University Press, 1953), 127–128, 143.

2. Panofsky, *Early Netherlandish Painting*, 186; on the larger theological implications of van Eyck's use of the *hortus conclusus*, Carol Purtle, *The Marian Paintings of Jan van Eyck* (Princeton, N.J.: Princeton University Press, 1982), 157–167. More generally, Reindert Falkenburg, *The Fruit of Devotion. Mysticism and the Imagery of Love in Flemish Paintings of*

the Virgin and Child, 1450–1550 (Amsterdam/Philadelphia: John Benjamins, 1994), esp. 8–21 and references at n.11; Mirella Levi d'Ancona, *The Garden of the Renaissance: Botanical Symbolism in Italian Painting* (Florence: L. Olschki, 1977). For the Master of the Frankfurt Paradise Garden, see Ewald Vetter, "Das Frankfurter Paradiesgärtlein," *Heidelberger Jahrbücher* 9 (1965): 102–146; the theme of the enclosed garden in general is discussed by Vetter, *Maria im Rosenhag* (Dusseldorf: L. Schwann, 1956).

3. For Dürer watercolors, still understudied, see Walter Koschatzky, *Albrecht Dürer. The Landscape Water-Colours* (New York: St. Martin's Press, 1973). The banks of open water do not correspond exactly to extant watercolors but do show elements of the south German subalpine lake region in the distant horizon of the print, while the buildings resemble steeply pitched wooden structures around Nuremberg's river, the Pegnitz, as shown in later watercolors, notably the large *Mills on a River Bank* (Koschatzky, no. 30; Paris, Bibliothèque Nationale; W. 113). A slightly earlier Dürer drawing (Berlin, W. 30) anticipates an image of the holy family on a grassy bench before a background landscape, albeit a constructed landscape of receding trees and distant peaks without open water. Among the elements in favor of an early date are the artist's undeveloped monogram, perhaps used here for the first time; in addition, the burin technique and modeling remain comparatively sketchy and irregular. See *Dürer in America: His Graphic Work*, exh. cat. (Washington, D.C.: National Gallery of Art, 1971), 112–113, no. 2, where the date of 1495–96 is suggested, in part because the landscape elements make it likely that the work was done after the artist's first trip to Italy. For the identification of the tiny insect as a mayfly and for a general discussion of this print and other Dürer images of the Madonna with animals, see Colin Eisler, *Dürer's Animals* (Washington, D.C.: Smithsonian Institution Press, 1991), 34–36, who argues that the short life of the mayfly underscores the brevity of Christ's time on earth. Certainly this particular identification of species is more plausible than most of the other insect names (dragonfly, cricket, butterfly, locust) that have been put forward by previous scholars, despite their differing body types.

4. For plants in general in German art of this period, Lottlise Behling, *Die Pflanze in der mittelalterlichen Tafelmalerei*, 2nd ed. (Cologne/Graz: Böhlau, 1967); see also Behling, "Betrachtungen zu einigen Dürer-Pflanzen," *Pantheon* 23 (1965): 279–291. A rigorous analysis of Dürer watercolors of plants (and imitations thereof) is given by Fritz Koreny, *Albrecht Dürer und die Tier- und Pflanzenstudien der Renaissance* (Munich: Prestel-Verlag, 1985), 176–253. There a close comparison to the several plants in the woodcut print is provided by no. 63, p. 182 (German, beginning of 16th century; Potsdam, Sanssouci, inv. 5360), where the combination of plants, identified by Koreny as goose-kress, common Ruchgras, and speedwell (Veronica). Of course, Dürer painted a celebrated watercolor in 1503, usually known as the *Great Clump of Turf* (Vienna, Albertina), discussed by Koreny as no. 61, 176–179, along with some other botanical representations by the artist. Koreny follows both Anzelewsky and Gombrich in suggesting a possible Neoplatonic goal of Dürer's immersion in such minutiae of nature, which might also be implicit in the use of the short-lived mayfly in his earlier engraving, and in his watercolor studies of plants and animals in general (see below). For a later illuminated botanical herbal, painted in Holland in the late sixteenth century (today Cracow, Jagiellonian University Library) for the pharmacist Theodorus Clutius, see Claudia Swan, *The Clutius Botanical Watercolors* (New York: Harry N. Abrams, 1998).

5. Behling, *Pflanze*, 132–136, figs. 19–20, 39; a similar plant occupies the center foreground of Pieter Bruegel's *Beekeepers* drawing (ca. 1568 Berlin), for which see Ethan Matt Kavaler, *Pieter Bruegel. Parables of Order and Enterprise* (Cambridge: Cambridge University Press, 1999), 233–254, but the plant is not discussed; also, *Pieter Bruegel d. Ä. als Zeichner: Herkunft Und Nachfolge*, exh. cat. (Berlin: Staatliche Museen Preussischer Kulturbesitz, 1975), 86–87, no. 100, where the plant is identified as mandrake (German *Alraune*), "a rare

plant, which according to superstition grows under the gallows and consequently is called 'Gallow youth' (*Galgenjunge*) or 'Gallow dwarf' (*Galgenmännlein*)." See also Richard Kieckhefer, *Magic in the Middle Ages* (Cambridge: Cambridge University Press, 1990), 13–14, 66.

6. Götz Pochat, *Der Exotismus während des Mittelalters und der Renaissance* (Stockholm: Almqvist & Wiksell, 1970), 118–136; Robert Koch, "Martin Schongauer's Dragon Tree," *Print Review* 5 (1976) *Tribute to Wolfgang Stechow*, ed. Walter Strauss, 114–119. The 1493 *Nuremberg Chronicle* woodcut of the Garden of Eden shows three trees: a date palm behind Adam, an apple tree with snake between the first parents, and a dragon tree behind Eve and next to the fountain of life, suggesting that it is to be equated with the scriptural Tree of Life. Bosch also puts the same three trees in his Paradise wing from the triptych of the *Garden of Earthly Delights* (Madrid, Prado); as Pochat recognized, the source for this imagery of animals is the pilgrimage guidebook *Peregrinatio in terram sanctam* by Bernhard von Breydenbach, published in Mainz in 1486.

7. For example, *Dürer in America*, 121, no. 14, citing H. W. Janson, *Apes and Ape Lore in the Middle Ages and Renaissance* (London: Warburg Institution, University of London, 1952), 151. Eisler, *Dürer's Animals*, 260–262, discusses monkeys at greater length.

8. Eisler, *Dürer's Animals*, 37, calls the bird a thrush and more explicitly associates its flight with the Resurrection; see also 56–91 for extended discussion on Dürer's birds of various species.

9. This same plant appears in a Leonardo da Vinci drawing (Windsor Castle, no. 12424) and in his two versions (Paris and London) of the *Madonna of the Rocks*. See Kenneth Clark, *Leonardo da Vinci*, rev. ed. (Harmondsworth: Penguin, 1988), 179, fig. 72; Martin Kemp, *Leonardo da Vinci* (Cambridge, Mass.: Harvard University Press, 1981), 273, fig. 74. To my knowledge this plant has not been identified in the Dürer *Madonna with the Monkey*.

10. Koschatzky, no. 25. This pond setting also resembles the background of the *Mayfly* engraving.

11. Eisler, *Dürer's Animals*, 31–55, with discussion of two other drawing versions, an earlier one in Berlin (W. 295), the other in Paris (1503; Louvre, W. 297). Koreny, *Albrecht Dürer*, 114–118, with full references.

12. For background on the print and the Dürer revival at the court of Rudolf II, see Dorothy Limouze, "Aegidius Sadeler," *Bulletin, Philadelphia Museum of Art* 85 (spring 1989), esp. 20 n. 22; for the Jan Brueghel, *Breughel-Brueghel*, exh. cat. (Essen, 1997), 169–171, no. 38.

13. For a later manifestation in the art of Albrecht Altdorfer of starbursts, coronas, and comets in the heavens above religious scenes of the early sixteenth century, see Larry Silver, "Nature and Nature's God: Landscape and Cosmos of Albrecht Altdorfer," *Art Bulletin* 91 (1999): 194–214. This earlier article suggests some of the arguments about macrocosm/microcosm resonances that are pursued further here.

14. Michael Baxandall, *The Limewood Sculptors of Renaissance Germany* (New Haven, Conn.: Yale University Press, 1980), 165–172.

15. Eisler, *Dürer's Animals*, 37–39, discusses the fox in this watercolor drawing as representing "the devil, to be caught by Christ's sacrifice." The two nearby owls also are often associated, as birds of night, with evil. On owls in Dürer, see Eisler, *Dürer's Animals*, 83–85. On the owl in the Netherlands tradition, see Paul Vandenbroeck, "Bubo significans I. Die Eule als Sinnbild der Schlechtigkeit und Torheit, vor allem in der niederländischen und deutschen Bilddarstellung und bei Hjeronimus Bosch," *Jaarboek Koninklijk Museum voor Schone Kunsten Antwerpen*, 1985, 19–136.

16. L. Naftulin comments on the presence of the parrot in van Eyck's *Madonna with Canon van der Paele* (Bruges, Groeninge Museum; 1434–36) in his "A Note on the Iconography of the van der Paele Madonna," *Oud Holland* 36 (1971): 7; see also Purtle, *Marian Paintings*, 92. Discussing the overall significance of the animals in Dürer's *Madonna with the Multitude of Animals*, Eisler, *Dürer's Animals*, 33, cites Francis of Retz's *Defensorum virginitatis Mariae*, a

book from the prior generation that used bestiary lore on animals to argue that their behavior heralded both the Immaculate Conception and the miraculous birth of Christ.

17. On flower symbolism in relation to the Virgin, by which her qualities are expressed through "similitudes" of the flowers to her beauty, purity, sorrow and the like, there is considerable literature. See, for example, Falkenburg, *Fruit of Devotion*, 10–11; Robert Koch, "Flower Symbolism in the Portinari Altarpiece," *Art Bulletin* 46 (1964): 70–77. Also Eisler, *Dürer's Animals*, 42–43.

18. Eisler, *Dürer's Animals,* 42–43, notes that "the hollyhock was believed to heal the bite of poisonous snakes, scorpions, and spiders, and thus, like Christ, to save humankind from the serpent–Satan."

19. *Lucas Cranach*, exh. cat. (Berlin, 1973), 13–14, no. 1; Hans Möhle, *Lucas Cranach d. Ä. Ruhe auf der Flucht nach Ägypten* (Stuttgart: Reclam, 1966); for the plants of the Berlin painting, see Behling, *Pflanze*, 120–121.

20. Panofsky, *Early Netherlandish Painting*, 146 n. 6, 333; Koch, "Flower Symbolism." On strawberries as the fruit of paradise, see Behling, *Pflanze*, 19; also James Mundy, "Gerard David's Rest on the Flight into Egypt: Further Additions to Grape Symbolism," *Simiolus* 12 (1981–82): 213–215; more generally, see Falkenburg, *Fruit of Devotion*.

21. The association of the finch with Christ's Passion derives in part from the blood-red mark on the bird's throat; see Herbert Friedmann, *The Symbolic Goldfinch* (New York: Pantheon Books, 1946).

22. M. R. James, *The Apocryphal New Testament* (Oxford: Clarendon Press, 1975), 49; for the text of Pseudo-Matthew and the miraculous fruit and spring, see 75.

23. Larry Silver, "Forest Primeval: Albrecht Altdorfer and the German Wilderness Landscape," *Simiolus* 13 (1983): 4–43, esp. 30–36; Franz Winzinger, *Albrecht Altdorfer. Die Gemälde* (Munich: R. Piper, 1975), 84–86, no. 27, dated there ca. 1513–15 but often situated somewhat earlier. This large work was once, probably originally, located in the monastery of St. Emmeram in Regensburg, where it is documented in the same century as its creation.

24. Behling, *Pflanze*, 125–129.

25. On "St. John's fire," in the context of Pieter Bruegel's 1560 *Children's Games* (Vienna, Kunsthistorisches Museum), see Sandra Hindman, "Pieter Bruegel's Children's Games, Folly, and Chance," *Art Bulletin* 63 (1981): 453–454, esp. n. 37. In commemorating a birthday and falling almost exactly six months away from Christmas itself, this holiday held special calendrical significance. This is the midsummer night alluded to as a lover's holiday by Shakespeare.

26. See Herbert Friedmann, *A Bestiary for St. Jerome* (Washington, D.C.: Smithsonian Institution Press, 1980), 291–293, for the snail; Eisler, *Dürer's Animals,* 119 (snail as a symbol of virginity), 127 (butterfly as image of the soul or Resurrection), 133–134 (snail's virginity tied to belief that air alone impregnated the animal).

27. Marjorie Lee Hendrix, "Joris Hoefnagel and the 'Four Elements': A Study in Sixteenth-Century Nature Painting," Ph.D. dissertation (Princeton University, 1984); Thomas DaCosta Kaufmann, *Drawings from the Holy Roman Empire 1540–1680*, exh. cat. (Art Museum, Princeton University, 1982), 154–157, no. 56.

28. Hendrix, *Joris Hoefnagel*, 215–262, esp. 219 n. 9. She points to the significance of beetles in the illustrations as examples of nature's own artifice and of the succeeding butterflies, both inscribed with biblical quotations such as Psalm 145:5 at folio 6: "They shall speak of the magnificence of the glory of thy holiness; and shall tell thy wondrous works." The last folio of Ignis (fol. 80) quotes Ecclesiasticus 43: "There are many things that are hidden from us that are greater than these: for we have seen but a few of his works." This is nature as both presentation of God's manifold glory as well as nature as enigma, shielding divine secrets. Hendrix points out 257, n. 16, that biblical quotations dominate the epigrams of the *Four Elements* illustrations:

thirty from Psalms, eight from Ecclesiasticus, eight from Isaiah, six from Proverbs, five from Job, and three from Ecclesiastes. See also her appendix of inscriptions, 263–332.

29. Winzinger, *Albrecht Altdorfer*, 75–77, no. 7.

30. Falkenburg, *Fruit of Devotion*, esp. 91–92, citing cherries in particular as "love fruit" in the convergence of erotic imagery of the Song of Songs with the Marian interpretation of divine love for humanity.

31. A fountain, of course, was also an important feature of the Garden of Eden, hence for enclosed gardens evocative of Paradise regained, such as Jan van Eyck's *Madonna of the Fountain* (1439; Antwerp); see Purtle, *Marian Paintings*, 163–166. Falkenburg, *Fruit of Devotion*, 10, refers to the Song of Songs' "sealed fountain and/or garden fountain, a well of living water" (4:12, 15), to be understood as a reference to the Virgin and her chastity. See also Friedrich Muthmann, *Mutter und Quelle: Studien zur ouellenverehrung im Altertum und im Mittelalter* (Basel: Archaölogischer Verlag, 1975), esp. 414.

32. Hans Mielke, *Albrecht Altdorfer*, exh. cat. (Berlin, 1988), 152, no. 73. The rich Renaissance ornament of this fountain further suggests its wonder, in contrast to the ornate Gothic vocabulary of actual contemporary fountains and the surrounding chapel space of the print. For the pictorial sources of the fountain and its relation to other Altdorfer works, see Franz Winzinger, "Der Altdorfer-Brunnen," *Jahrbuch der Berliner Museen* 13 (1963): 27–32. Here as well as in the Berlin painting the presence of accompanying angels and a pagan deity atop the fountain suggest the supernatural forces at work in its manifestation. Mielke points out a logical fact: that during the lifetime of the holy figures, only pagan deities could have been publicly presented; however, as will be discussed below, it is possible to interpret these deities as linked to planetary gods and thus to the natural forces inherent to both alchemy and astrology in this period.

33. Dürer painted the scene of *Hercules Slaying the Stymphalian Birds* (Nuremberg, Germanisches Nationalmuseum; on canvas) for the court of Frederick the Wise in Saxony; see Fedja Anzelewsky, *Albrecht Dürer. Das malerische Werk* (Berlin: Deutscher Verlag für Kunstwisssenschaft, 1971), 168–170. For another German painting of a bearded Apollo with bow and arrow, see the 1530 Lucas Cranach work, *Apollo and Diana* (Berlin; exh. cat., 1973, 21–22, no. 10). The nude Altdorfer figure also lacks the most characteristic marks of Hercules: his club and his lionskin mantle.

34. Rarely analyzed, this drawing does receive attention from Eisler, *Dürer's Animals*, 156–157, plate 22, who follows G. F. Hartlaub ("Albrecht Dürers 'Aberglaube,'" *Zeitschrift des deutschen Vereins für Kunstwissenschaft* 7 [1940], 183–184 n. 23), in asserting that the egg might well be "an alchemical image of the 'philosopher's egg,' that egg-shaped vessel for thought and matter." Hartlaub claims that the Altdorfer fountain in the Berlin painting represents the "bath of Mary" (*balneum Mariae*), which corresponds to alchemical writings that discuss distillation as an act of purification, akin to the rite of baptism. There is also an association in alchemy between virginity and the *prima materia*. A related drawing, also dated 1513, Eisler's plate 36 (Berlin; W. 703) shows a tall bird, a crane (or a heron) with talonlike feet, standing tall. This bird is associated with vigilance (Eisler, 72, citing Ambrose as well as Dürer's own marginal illustrations around the same time for the "translated" *Hieroglyphica* of Horus Apollo), so it also has a virtuous character, appropriately paired with the strengths of the lion.

35. Eisler, *Dürer's Animals*, 139–161, discusses lions in general along with their varied inclusions in Dürer's oeuvre. For the bestiary lore, based on a translation of a twelfth-century "book of beasts," see T. H. White, *The Bestiary: A Book of Beasts* (New York: Putnam's, 1960), 7–11, which makes explicit the identification with Christ by analogizing and allegorizing the qualities of the animal with the mission and nature of the Savior.

36. "Lutum sapientiae" could also refer to the mixture of clay, hair, straw, and horse dung that was used to seal and protect glass vessels from breakage when they were placed in the flames of the distilling furnace.

37. Richard Kieckhefer, on "Arabic Learning and the Occult Sciences," *Magic in the Middle Ages*, 116–150, esp. 144–150 on the Renaissance magus and the intensified interest in Hebrew Kabbalah as an additional source for occult knowledge and potential magical incantation. Wayne Shumaker, *The Occult Sciences in the Renaissance: A Study of Intellectual Patterns* (Berkeley and Los Angeles: University of California Press, 1972), esp. 201–251 on Hermes Trismegistus and associations of occult learning with ancient Egypt. See also D. P. Walker, *Spiritual and Demonic Magic from Ficino to Campanella* (London: Warburg Institute, 1958), esp. 117–156; Frances Yates, *Giordano Bruno and the Hermetic Tradition* (Chicago: University of Chicago Press, 1964), esp. 75–96.

38. G. F. Hartlaub, "Albrecht Dürer's 'Aberglaube,'" and "Arcana artis. Spuren alchemistischer Symbolik in der Kunst des 16. Jahrhunderts," *Zeitschrift für Kunstgeschichte* 6 (1937): 289–324, interpreted Dürer's alchemical imagery as the manifestation of the long enduring workings of the human subconscious. More recently, historians have claimed that Dürer's *Melencolia I* concerns the first stage of the alchemical process: Maurizio Calvesi, *La melencolnia di Albrecht Dürer* (Turin: G. Einaudi, 1993). James Elkins and Didier Kahn have debated the value of such research: James Elkins, "On the Unimportance of Alchemy in Western Painting," *Konsthistorisk tidskrift* 1, no. 1–2 (1992): 21–26, and "Reply to Didier Kahn: What is Alchemical History?" *Konsthistorisk tidskrift* 64, no. 1 (1995): 51–53; Didier Kahn, "A propos de l'article de James Elkins: On the Unimportance of Alchemy in Western Painting," *Konsthistorisk tidskrift* 64, no. 1 (1995): 47–51.

39. Cennino D'Andrea Cennini, *The Craftsman's Handbook (Il libro dell'Arte)*, trans. Daniel V. Thompson Jr. (New York: Dover, 1960), lists the colors made by "alchemy" as vermilion, red lead, orpiment yellow, arzica yellow, verdigris, and white lead (24, 25, 28, 30, 33, 34). Other colors fell into the categories of "natural" or "artificial" (but not manufactured by alchemy). See also A. Wallert, "Alchemy and Medieval Art Technology," in *Alchemy Revisited*, ed. Z. R. W. M. von Martels (Leiden: Brill, 1990).

40. Jacques van Lennep, *Alchemie. Bijdrage tot de geschiedenis van de alchemistische kunst* (Brussels: Gemeentekrediet, 1984) argues that artists' distillation procedures for producing varnishes were regarded as alchemy. Similarly, Laurinda S. Dixon, "Bosch's *Garden of Delights* Triptych: Remnants of a 'Fossil' Science," *Art Bulletin* 63 (1981): 96–113; *Alchemical Imagery in Bosch's Garden of Delights* (Ann Arbor: UMI Research Press, 1981); and "Bosch's 'St. Anthony Triptych'—An Apothecary's Apotheosis," *Art Journal* (summer 1984), maintains that Bosch's familial ties to apothecaries and their procedures of alchemical distillation account for much of the imagery in Bosch's paintings. While both these authors make their arguments in general and expansive terms, they do point out an important convergence between alchemical and artisanal activities, in which material transformation of any sort could be regarded as alchemical. For an interesting recent meditation on the overlap between alchemy and artists' practices, see James Elkins, *What Painting Is: How to Think about Oil Painting Using the Language of Alchemy* (New York: Routledge, 1999).

41. Juan Luis Vives, *De tradendis disciplinis*, 1531, trans. Foster Watson (Totowa, N.J.: Rowman and Littlefield, 1971), 209.

42. For the relationship between scholars and artisans, see Elsbeth Whitney, *Paradise Restored: The Mechanical Arts from Antiquity through the Thirteenth Century*, Transactions of the American Philosophical Society, vol. 80 (Philadelphia, 1990); Paolo Rossi, *Philosophy, Technology, and the Arts in the Early Modern Era*, trans. Salvator Attanasio (New York: Harper & Row, 1970); William Eamon, *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture* (Princeton, N.J.: Princeton University Press, 1994); Pamela O. Long, "Power, Patronage, and the Authorship of *Ars*," *Isis* 88 (1997), 1–41; and R. Hooykaas, "The Rise of Modern Science: When and Why?" *British Journal for the History of Science* 20 (1987): 453–473.

43. On the connections between artisanal epistemology and the later New Philosophy of the sixteenth and seventeenth centuries, which helped to shape attitudes toward nature and the pursuit of knowledge about nature in the new science, see Pamela H. Smith, "Artists as Scientists: Nature and Realism in Early Modern Europe," *Endeavour* 24 (2000): 13–21; idem, "Science and Taste: Painting, the Passions, and the New Philosophy in Seventeenth-Century Leiden," *Isis* 90 (1999): 420–461.

44. Christ was likewise frequently associated with Apollo or with the "true sun," *Sol Justitiae*. See also images from the Early Christian period, esp. the Jewish mosaics at Beth Alpha and Hamat synagogues in modern Israel, which feature Apollo in his solar chariot at the center of the zodiac within an alien religious setting (Bezalel Narkiss, "The Jewish Realm," in *Age of Spirituality*, ed. Kurt Weitzmann, exh. cat., New York, 1979, 374–375, no. 342). For Apollo and Christ in Early Christian art, see the mosaic in the Mausoleum of the Julii under St. Peter's basilica in Rome, late third century, where the nimbus around the head of the charioteer Helios/Apollo transfers divine imaging to the figure of Christ, ascending into heaven on the chariot and representing the "victorious sun," *Sol invictus,* for which see Marilyn Stokstad, *Medieval Art* (New York: Harper and Row, 1986), 15–17, fig. 14. Another important connection between Christ and the image of the sun, specifically by Dürer in his engraving *Sol Justitiae* (ca. 1500; B. 79), where the judging God rides upon a lion. This almost neglected print, so redolent of ancient solar iconography transposed into a Christian context, was discussed by Erwin Panofsky, "Albrecht Dürer and Classical Antiquity," *Meaning in the Visual Arts* (New York: Doubleday, 1955), 256–265, also discussing the late antique spirituality tied to "astral mysticism," which even led to Augustine's warning against carrying the identification of Christ with Sol so far as to relapse into paganism (260). Altdorfer's muscular Apollo on the Berlin fountain also resembles the figure type (again without beard) and pose used by Dürer in his drawings of Apollo (W. 261–64), nude and holding an orb in his left hand, for example, the famous Apollo with Diana (London, British Museum, W. 261; Panofsky, fig. 76). While Altdorfer's access to such drawings remains unknown, even doubtful, a more public, visible touchstone of this figure concept by Dürer would have been the engraving *Apollo and Diana* (ca. 1502; Meder 64), where the muscular god (beardless) carries a bow and quiver of arrows and wears a laurel wreath. In this context, it is worth noting the importance of Altdorfer's equation of the *Resurrection* (1518; Vienna) with the rising sun; see Silver, "Nature and Nature's God," 199–201. For Dürer's equation of the resurrected Christ with an Apollonian sun god, see Panofsky, 260–261 n. 77, fig. 81, citing the Latin poem by Benedictus Chelidonius on the reverse of the Small Woodcut Passion *Resurrection* woodcut, translated as follows: "This is the day on which the Creator began to make the world, dedicated, according to the perennial belief, to the Lord of Heaven and Phoebus. On this day the all-seeing Sun, affixed to the cross, hidden and dying when the sun set in darkness, splendidly reappeared when it rose." Moreover, Dürer wrote: "Then, at the same time, as they [the artists of antiquity] attributed the most beautiful human figure to their idol, Apollo, we would praise Christ the Lord, who is the most beautiful in all the world. And as they praised Venus as the most beautiful woman we would ourselves set forth the gracious figure of the most pure maiden Mary the Mother of god. And for Hercules we would substitute Samson, and we would do the same with all the other [gods]." Hans Rupprich, *Dürer's schriftlicher Nachlass,* 3 vols. (Berlin: Deutscher Verein für Kunstwissenschatt, 1956–69), 2: 103ff.

45. Eggs also could be specifically associated with the Incarnation of Christ. In particular, the ostrich egg included by Piero della Francesca above the central holy figures in his *Madonna and Child with Saints* (Milan, Brera) has been interpreted as a symbol of supernatural birth. See Millard Meiss, "Ovum Struthionis: Symbol and Allusion in Piero della Francesca's Montefeltro Altarpiece," *The Painter's Choice. Problems in the Interpretation of Renaissance Art* (New York: Harper and Row, 1976), 105–129. This supernatural role of an

egg's miraculous powers is especially true for an ostrich egg, hatched only by the rays of the sun according to medieval bestiaries. White, *The Bestiary*, 121–122, speaks of the incubation in warm sand. This link between the sun and the eggs corresponds to Altdorfer's association of Apollo and the hatching egg within his hand.

46. H. J. Sheppard, "Egg Symbolism in Alchemy," *Ambix* 6 (1958): 140–148, 144.

47. See the work of Allen G. Debus, B. J. T. Dobbs, and, briefly, E. J. Holmyard, *Alchemy* (New York: Dover, 1990; reprint of 1957 ed.) and John M. Stillman, *The Story of Alchemy and Early Chemistry* (New York: Dover, 1960; reprint of 1924 ed.). In the sixteenth century, Theophrastus von Hohenheim, called Paracelsus (1493–1541), added a third principle–salt–to sulfur and mercury, probably reflecting the importance of the production of salts beginning in the fourteenth century. Gunpowder, saltpeter (from which fertilizer was produced), and the preservative properties of common salt came to have increasing importance in the fourteenth and fifteenth centuries.

48. Sulfur appears in a pure form in nature. On heating, it turns a dark red color, which when rapidly cooled forms a glassy red substance. Similarly mercury is found in a pure form in nature.

49. For an excellent discussion of the significance of mercury in alchemical theory, see Karin Figala, s.v. "Quecksilber," *Alchemie. Lexikon einer hermetischen Wissenschaft*, ed. Claus Priesner and Karin Figala (Munich: Beck, 1998), 295–300; see B. J. T. Dobbs, *The Foundations of Newton's Alchemy* (Cambridge: Cambridge University Press, 1975), 35–37, for the matter/spirit problem in alchemy.

50. Figala, "Quecksilber," 298.

51. Hie ist geboren Solis und Lüne kindt/ Desgleichen nyemant auf Erden findt/ Und in die weldt doch gern erkhennt/ Mercurius philosophorum ist Er gennent.

52. Dobbs, *Foundations of Newton's Alchemy*, 184–185.

53. In alchemical theory and practice, the conception of nature as actively creating, and of *ars* as knowing how to reproduce the natural processes of creation and generation, had long predated the arrival of the Hermetic corpus. See William Newman, "Technology and Alchemical Debate in the Late Middle Ages," *Isis* 80 (1989): 423–445; idem, "Art, Nature, and Experiment in Alchemy," in *Texts and Contexts in Ancient and Medieval Science*, ed. Edith Scylla and Michael McVaugh (Leiden: Brill, 1997), 304–317; idem, *The Summa perfectionis of Pseudo-Geber* (Leiden: Brill, 1991).

54. Quoted by Jan Bialostocki, "The Renaissance Concept of Nature and Antiquity," *The Renaissance and Mannerism* 2 (Princeton, N.J.: Princeton University Press, 1963), 19–30, esp. 25, quoted as an atypical statement of Leonardo, taken from Neoplatonic views that the world was animated. Although this idea was certainly expressed, particularly by Marsilio Ficino, much older sources were available to artists and artisans. One author who regards Leonardo's comments on the vital forces of nature as extremely significant, though he does not precisely know how to categorize them (he calls them "myth"), is James Ackerman, "Science and Art in the Work of Leonardo," in *Leonardo's Legacy*, ed. C. D. O'Malley (Berkeley and Los Angeles: University of California Press, 1969), 222ff. See also Martin Kemp, *Leonardo da Vinci. The Marvellous Works of Nature and Man* (Cambridge: Harvard University Press, 1981), esp. 263, 277 on the earth as an organism with geological flux; 312–319 on the relationship between this geology and the system of the four elements.

55. Karel van Mander, *The Lives of the Illustrious Netherlandish and German Painters from the First Edition of the Schilder-boeck (1603–04)*, trans. and ed. Hessel Miedema (Doornspijk: Davaco, 1994); see esp. the lives of Lucas van Leyden (1: 104–105, with commentary 3: 2), Spranger (1: 330–331; commentary 5: 87), and Aert Mijtens (1: 313; commentary 4: 24).

56. This goal of mirroring nature was the fundamental ambition of Netherlandish painting, for which, see Hans Belting and Christiane Kruse, *Die Erfindung des Gemäldes. Das erste*

Jahrhundert der niederländischen Malerei (Munich: Hirmer, 1995), with references; see also the classic study by Erwin Panofsky, *Early Netherlandish Painting* (Cambridge: Harvard University Press, 1953), esp. the discussion "Reality and Symbol in Early Flemish Painting," 131–148, and the discussion of the epitome of this ambition, Jan van Eyck: "Thus Jan van Eyck's style may be said to symbolize that structure of the universe which had emerged, at his time, from the prolonged discussion of the 'two infinites'; he builds his world out of his pigments as nature builds hers out of primary matter. The paint that renders skin, or fur, or even the stubble on an imperfectly shaved face seems to assume the very character of what it depicts; and when he paints those landscapes which, to quote Fazio once more, 'seemed to extend over fifty miles,' even the most distant objects, however much diminished in size and subdued in color, retain the same degree of solidity and the same fullness of articulation as do the very nearest. Jan van Eyck's eye operates as a microscope and as a telescope at the same time" (181-182). Here it is worth recalling that Jan van Eyck was (falsely) credited as being the inventor of oil paint technique, surely a form of chemistry/alchemy, for which he was praised in the following century in the *Lives of the Artists* by Vasari (1566), who states in the life of Antonello da Messina that one Jan of Bruges, "a painter very much esteemed for the practice which he had acquired in becoming a master . . . began to try [provare] different sorts of colors, especially those which pleased him from alchemy, to make an oil to use as a varnish and other things, according to the notions of the learned men of that age." Cited from the edition of Rosanna Bettarini (Florence: Sansoni, 1971), Vol. 3, 302.

57. Quoted by Panofsky, *Early Netherlandish Painting,* 2, with full citation.

58. Bialostocki, "Renaissance Concept of Nature and Antiquity"; E. H. Gombrich, "The Style All' Antica: Imitation and Assimilation," *The Renaissance and Mannerism* 2: 31–40; Ernst Kris, "Georg Hoefnagel und der wissenschaftliche Naturalismus," *Festschrift für Julius Schlosser zum 60. Geburtstag*, ed. Arpad Weixlgärtner and Leo Planscig (Zurich: Amalthea, 1927); Otto Pächt, "Early Italian Nature Studies and the Early Calendar Landscape," *Journal of the Warburg and Courtauld Institutes* 13 (1950): 13–46.

59. Elisabeth Dhanens, *Van Eyck: The Ghent Altarpiece* (New York: Viking, 1973), 80. Wisdom 7: 29, 26.

60. From book 3 of his work on human proportions, *Vier Bücher von menschlicher Proportion*, 1528, trans. and quoted by Erwin Panofsky, *The Life and Art of Albrecht Dürer* (Princeton: Princeton University Press, 1955), 279–280.

61. Walter Pagel, *Paracelsus. An Introduction to Philosophical Medicine in the Era of the Renaissance*, 2nd ed. (Basel: Karger, 1982), 51.

62. Paracelsus, *Das Buch Labyrinthus medicorum genant* (1538, 1st publ. ed. 1553), in Vol. 11 of *Sämtliche Werke*, ed. Karl Sudhoff (Munich/Berlin: Oldenbourg, 1928), 163–221, chap. 6, 192. Paracelsus also stated that knowledge (*erkantnus*) is not in the physician but in nature, as are the disease and the cure. *Das Buch Paragranum* (1530), in Vol. 8 of *Sämtliche Werke,* ed. Sudhoff (Munich: Barth, 1924), 140. Pagel, *Paracelsus*, 51, 218–223, notes the Neoplatonic overtones of this passage, but in this and other essays, he also points out the multiple sources for Paracelsus's work, including popular pantheism, Salomo ibn Gebirol's (1021–70) notion of "prime matter" (229–230), and medieval alchemical treatises (259ff.). See also Walter Pagel, "Paracelsus and the Neoplatonic and Gnostic Tradition," *Ambix* 8 (1960): 125–166.

63. Ernst Kris, "Der Stil 'Rustique': Die Verwendung des Naturabgusses bei Wenzel Jamnitzer und Bernard Palissy," *Jahrbuch der Kunsthistorischen Sammlungen in Wien* N.F. 1 (1928), 137–207, esp. 147; see also Klaus Pechstein, "Der Goldschmied Wenzel Jamnitzer," *Wenzel Jamnitzer und die Nürnberger Goldschmiedekunst 1500–1700*, exh. cat. (Nuremberg: Germanisches Nationalmuseum, 1985), 60, 219–223, 342–343, nos. 15–16, 299, esp. the Merkel Centerpiece, dated 1549.

64. Quoted in Wenzel, *Jamnitzer*, 220, no. 15: "Sum terra Mater Omnium/ Omusta caro pondere/Nascentium ex me fructuum."

65. Although this aspect of the thought of Paracelsus has usually been attributed to Neoplatonic influences, two recent works have suggested the vernacular nature of his ideas. For example, Stefan Rhein, "'Mein bart hat mer erfaren dan alle euer hohe schulen'. Ein Zwischenruf zur Quellenfrage bei Paracelus," 99–104, and Gundolf Keil, "Mittelalterliche Konzepte in der Medizin des Paracelsus," 173–193 in *Paracelsus. Das Werk–die Rezeption,* ed. Volker Zimmermann (Stuttgart: Steiner, 1995).

66. Paracelsus, *Astronomia magna: oder die gantze Philosophia sagax der grossen und kleinen Welt/ des von Gott hocherleuchten/ erfahrnen/ und bewerten teutschen Philosophi und Medici* (finished 1537–38; 1st publ. ed. 1571); in Vol. 12 of *Sämtliche Werke*, ed. Karl Sudhoff (Munich/Berlin: Oldenbourg, 1929), 1–444, esp. 56.

67. Bernard Palissy, *The Admirable Discourses*, 1580, trans. Aurele la Rocque (Urbana: University of Illinois Press, 1957), 188–203; for an illuminating discussion of this point, see Neil Kamil, "War, Natural Philosophy and the Metaphysical Foundations of Artisanal Thought in an American Mid-Atlantic Colony: La Rochelle, New York City, and the Southwestern Huguenot Paradigm, 1517–1730," Ph.D. dissertation (Johns Hopkins University, 1988). The most important recent works on Palissy are: *Bernard Palissy: Mythe et Réalité* (Niort, Saintes: Museés d'Agen, 1990); Bernard Palissy, *Recepte véritable* (Geneva: Droz, 1988), with introduction by Keith Cameron; Frank Lestringant, ed., *Barnard Palissy 1510-1590. L'Écrivain, Le Réformé, Le Céramiste* (Coédition Association Internationale des Amis d'Agrippa d'Aubigné, 1992); Leonard Amico, *Bernard Palissy: In Search of Earthly Paradise* (Paris/New York: Flammarion, 1996); and the recent exhibition catalog, *Un Orfèvre de Terre: Bernard Palissy et la Céramique de Saint-Porchaire* (Chateau D'Écouen, 1997). Also, with an emphasis on Palissy's Calvinist minority status and architectural and garden designs, Catherine Randall, *Building Codes. The Aesthetics of Calvinism in Early Modern Europe* (Philadelphia: University of Pennsylvania Press, 1999), 44–77. See also Kris, "Stil rustique."

68. Benvenuto Cellini, *Autobiography*, trans. George Bull (Harmondsworth: Penguin, 1956), 343–358, discussed (partly in terms of alchemy) by Michael Cole, "Cellini's Blood," *Art Bulletin* 81 (1999), 215–235. Here the crucial element of the image is precisely its metallic substance and its forging in the crucible of a furnace with the addition of "spirits" to resuscitate the dead metal into flowing, corporeal vitality.

69 While today "Abmachen" means to undo, Panofsky translated Dürer's use here as "reproducing nature from life." (Erwin Panofsky, *Idea. A Concept in Art Theory,* trans. Joseph J. S. Peake [Columbia: University of South Carolina Press, 1968, 121–126.) In Dürer's usage, it was probably closer to the modern "abschreiben," or copying verbatim. Dürer also used the term "abkunterfet" to mean portraying after life or with verisimilitude. Similarly Paracelsus used "ablernen" to denote the process of learning the "scientia" from the plant itself. Paracelsus, *Labyrinthus*, 191.

70. Panofsky, *Art and Life of Albrecht Dürer*, 243–244, discussing the artist's "individual struggle with reality"; Panofsky, *Idea*, 121–126, esp. 123, characterized here as a unique combination in Dürer of contemporary Italian art theory, influenced by Neoplatonism, and the artist's own, "personal," here characterized as artisanal, vision of his creative process. This combination of study from nature and evocation from the memory and spirit corresponds fairly closely to what Dutch art theory at the turn of the seventeenth century, exemplified by Karel van Mander would discuss in the contrasting terms "after life" (*naer het leven*) and "from the spirit/memory " (*uyt den geest*). See Walter Melion, *Shaping the Netherlandish Canon. Karel van Mander's Schilder-Boeck* (Chicago: University of Chicago Press, 1991), esp. 63–66, 243 n. 10.

71 "Effects" were synonymous with the products of (al)chemical experiments and with works of art. For example, Lorenzo Ghiberti's called his naturalistic relief panels on the doors of the Florence baptistery (1425–52) the "effeti" of the biblical stories illustrated in each one. Julius von Schlosser, *Lorenzo Ghiberti's Denkwürdigkeiten (I Commentarii)*, 2 vols. (Berlin: Julius Bard, 1912), Vol. 1: 49.

72. Paracelsus believed that an artisan must perfect the art of reading a thing from its external character through experience, thus understanding the virtue and power of the material, what he calls "chiromancy": "People who work wood, carpenters, joiners and such, have to understand their wood by the chiromancy of it, what it is apt and good for." In the same way a miner will know the chiromancy of the mine. Paracelsus, *Liber de imaginibus*, vol. 11 of *Sämtliche Werke*, ed. Karl Sudhoff (Munich/Berlin: Oldenbourg, 1931), 361–386, esp. 375–376. This translation is taken from Baxandall, *The Limewood Sculptors*, 160, who finds that Paracelsus "throws a more penetrating light on the characteristic forms of sculpture than anything else available."

73. Paracelsus, *Die neun Buecher De Natura rerum* (1537), book 1 in Vol. 11 of *Sämtliche Werke,* ed. Sudhoff, 314.

74. Hartmut Krohm and Jan Nicolaisen, *Martin Schongauer. Druckgraphik* (Berlin: Staatliche Museen, 1991), 83–84, no. 3c (Lehrs 7). For the identification of the Tree of Life as a derivation of the exotic "dragon tree," see Robert Koch, "Martin Schongauer's Dragon Tree"; also Götz Pochat, *Der Exotismus*, 118–136.

75. Robert Koch, "The Salamander in Van der Goes' Garden of Eden," *Journal of the Warburg and Courtauld Institutes* 28 (1965): 323–326; also White, *Bestiary*, 182–184; Edward Topsell, *The Elizabethan Zoo* (Boston: Nonpareil, 1979), 108–115. Benvenuto Cellini's first childhood memory was of seeing a salamander in the fire (*Autobiography*, 20).

76. White, *Bestiary*, 125–128; Topsell, *Elizabethan Zoo*, 22–23; Herbert Kessler, "The Solitary Bird in Van der Goes' Garden of Eden," *Journal of the Warburg and Courtauld Institutes* 28 (1965), 326–329.

77. See the equation of Mary with the fountain in Jan van Eyck's *Madonna of the Fountain* (1439; Antwerp, Koninklijk Museum), as noted above, n. 31. Purtle, *Marian Paintings*, 157–167; Larry Silver, "Fountain and Source: A Rediscovered Eyckian Icon," *Pantheon* 41 (1983): 95–104; Paul Vandenbroeck, *Catalogus Schilderkunst 14e-15e eeuw* (Antwerp: Koninklijk Museum, 1985), 174–178. The fountain as a Marian symbol derives from passages in the Song of Songs, 4:15, where the beloved is described as "a garden fountain, a well of living water, and flowing streams from Lebanon."

Objects of Art/Objects of Nature

Visual Representation and the Investigation of Nature

PAMELA O. LONG

This essay explores some of the ways in which visual representation came to legitimate knowledge claims in the period between about 1490 and the 1540s. The use of images to further knowledge about the natural world represents a significant cultural development. For both philosophical and historical reasons, ancient and medieval thought tended to separate things made by human artifice—paintings and drawings, as well as constructed objects such as machines—from the natural world. In part, this reluctance to use visual images to demonstrate claims about the world came out of the Aristotelian view that art and nature were opposed to one another.[1]

Alan Gabbey frames the issue as it concerns mechanics. He points to the traditional separation between the mechanical arts and Aristotelian physics. For Aristotle, machines and devices rearrange things *against* nature and for human ends; they belong to mechanics as a practical art. The theoretical discipline of physics did not include an interest in mechanical devices or their specific effects in the world. Physics "did not share the concerns of mechanics, since physics did not deal with artificial things *qua* artificial." Traditional Aristotelian definitions of *physica*, *philosophia naturalis*, or *physiologia* concern "the science [*scientia*] of natural bodies *in so far as they are natural*." Gabbey investigates the ways in which mechanical arts became mechanics, a discipline in which the ancient distinctions between the mechanical arts and *physica* or natural philosophy came to be seriously eroded or eliminated. Thereby could seventeenth-century experimental philosophers use machines and devices to demonstrate claims about the natural world.[2]

Yet the transformation involving mechanical arts and mechanics is just one episode in a larger cultural development in which the artifactual and the natural moved into closer proximity. The use of visual images (created

by human artifice) to represent observed natural objects had to overcome serious impediments, including a focus on the capacity of drawings and paintings to create optical illusions. In ancient times, as the story of Zeuxis attests, the most skillful painter is the one whose painting is radically deceptive. The story as told by Pliny recounts the rivalry of Zeuxis and Parrhasius. Zeuxis, attemping to demonstrate his superiority as a painter, produced a picture of grapes so expertly that birds flew up to it. Then Parrhasius created a picture of a curtain so realistic that Zeuxis, "proud of the verdict of the birds, requested that the curtain should now be drawn and the picture displayed." When he discovered that the curtain was actually a painting by Parrhasius he honorably yielded the prize to him.[3] The story emphasizes the remarkable skill and ingenuity of the painters, but it hardly offers visual representation as a modality for demonstrating truths about the natural world. It underscores instead the capacity of humans both for creating optical illusions and for being deceived by them.

The inherent capacity of visual images to deceive made them suspect as aids to discovering truths about nature. This suspicion was augmented by the sharp medieval social divisions between those who studied natural philosophy at the universities and those who produced images in workshops. Scholastic natural philosophy was not fundamentally experimental, observational, or visual, but was logical and textual involving extensive commentaries, lectures, and formal disputations based on the study of authoritative writings. Artisanal practitioners did not attend universities, but were trained by apprenticeship in workshops. The mechanical arts and natural philosophy were separated physically and socially, as well as conceptually.[4]

Yet gradually during the fifteenth and sixteenth centuries in settings outside of the universities in cities and courts, humanists and others combined an interest in learning with a preoccupation with the constructive arts. The basic context for such a development involves medieval commercial capitalism and urbanism in which the production and exchange of all kinds of goods was aided by the expansion of both local and distant markets. Worldly goods proliferated just as the cultural value of material objects increased. Elite rulers undertook massive building programs to reorganize the urban spaces that they controlled and to legitimate their own power. From the late-fifteen century, they increasingly practiced conspicuous consumption. Finely wrought objects, including paintings, sculpture, and other forms of visual representation gained cultural value.[5]

At the same time, learned culture expanded beyond the universities as humanists took positions as secretaries in cities and courts, or found patronage from oligarchs and princes who also employed workshop-trained painters, architects, and engineers. Across Europe, in many courts and cities, learned humanists, wealthy patrons, and artisan-trained painters, sculptors,

and architects lived in closer proximity—both physically and in terms of their mutual interests—than they had in previous centuries. Artisan-trained individuals sometimes wrote treatises about their crafts. Learned humanists such as Leon Battista Alberti also wrote treatises and commentaries on painting, architecture, and other constructive arts.[6] These broad cultural developments took place in the context of a thriving commercial culture involving the production and exchange of everyday and luxury goods within both local and European-wide markets. One result was that objects fabricated by humans, including visual images, came to be used for the study of the natural world.

This essay examines a group of diverse sources in an investigation of the ways in which art and nature came to be closely associated or even interchangeable between the 1490s and the 1540s. Sources include a lengthy architectural romance, the *Hypnerotomachia Poliphili* [*Struggle of Poliphilus in a dream*], a literary work published in 1499; Leonardo da Vinci's *Madrid Codex I*, an extensively illustrated manuscript treatise on machines and mechanics created in the 1490s; some of the paintings and writings of Albrecht Dürer; the treatise on the architectural orders by Sebastiano Serlio, published in 1537; and finally, Andreas Vesalius's famous anatomical treatise, the *De Humani Corporis Fabrica*, published in 1543.[7]

These sources are often placed in separate disciplinary categories. The *Hypnerotomachia Poliphili* is a literary work of interest to architectural and literary historians. *Madrid Codex I* falls into the category of mechanics and is of interest to historians of science. Dürer's paintings and prints are studied primarily by art historians. Serlio is studied by architectural historians, whereas Vesalius draws the attention of historians of anatomy, medicine, and science. Yet these modern disciplinary categories are at least in part anachronistic. They tend to separate these works one from another in ways that are inappropriate for the sixteenth century, obscuring their common culture.

The sources considered here share several characteristics. In diverse ways, for example, they display close relationships, and even interchangeability between artificial and natural objects. This interchangeability is particularly evident in the *Hypnerotomachia Poliphili*, and it is explicit or implicit in the other sources as well. Analogies between natural and artificial objects, and the use of one to demonstrate a truth about the other, are evident in most of them. Leonardo, for example, uses the motions of actual and visually depicted machines to explore principles of motion. Dürer creates the first free-standing images of landscapes and creates other "slices" of the natural world by means of art. Vesalius in his anatomical treatise uses methods strikingly similar to those that Serlio used in his earlier treatise on architecture. He also compares anatomical structures such as bones to artificial structures such as the beams of houses. While the differences among these works are

apparent, they share a tendency to closely associate objects of art and objects of nature.

ART AND NATURE IN THE HYPNEROTOMACHIA POLIPHILI

The *Hypnerotomachia Poliphili*, published in 1499, was written possibly by one Francesco Colonna, who probably can be identified as a Dominican monk of Venice of the same name. The authorship of the work is controversial. Whoever Francesco Colonna was, his complex romance encompasses a dream within a dream in which Poliphilo walks through a varied terrain filled with pyramids, ruins, gardens, forests, meadows, and streams, as he searches for his lost love, Polia.[8]

For my purposes here, *Hypnerotomachia Poliphili* is interesting because of the author's persistent interest in itemizing objects of nature and objects of art, including architectural fragments, in profuse detail, and also because of his habit of interchanging constructed artifacts and natural things. For example, at one point in his dream within a dream, Poliphilo comes to an enclosed valley where he encounters an enormous half-ruined pyramid carved out of the surrounding mountains and topped by an obelisk that is dedicated to the sun. The author provides a detailed description of the monument itself including structures, ornamental details, fragments of sculpture and architecture, inscriptions, and the names of many varieties of herbs and grasses growing among the ruins. Poliphilo hears frightening groans and discovers that they are emitted by the colossal statue of a man. The groans are caused by wind blowing through the open mouth of the colossus. Using the hairs of the chest and beard of the statue, Poliphilo pulls himself into the open mouth and then climbs through the viscera. Each part of the body, "intestines, nerves, bones, veins, muscles, and flesh" is present, and each is labeled in Chaldean, Greek, and Latin. The inscribed body parts describe what sickness is generated in each part, the cause, the required care, and the remedy.[9]

Poliphilo emerges from this polyglot body, and looks at other ruins such as the colossal statue of a horse that "seemed almost to tremble in its flesh, and more alive than fabricated." He enters the pyramid through the great portal, encounters a dragon and other amazing things, emerges from the bowels of the great structure into a lovely meadow. He describes the meadow by providing an encyclopedic enumeration of the specific varieties of plants and trees. As he continues on his journey he describes an ancient bridge over a stream with overgrown banks populated with many varieties of birds, and then a plain filled with creatures, flowers, and fruit trees, each of which he specifies by name. He meets the nymphs of the five senses, whose clothing he describes minutely. He finally arrives at the palace of the

Queen Eleuterilyda (free thought), and describes the approach to the palace where the nymphs take him first to the baths. As he draws near to the palace and enters, he describes the courtyard, the exterior, the ornamentation of the entrance, the ornate tapestries of the successive rooms, the decorations, the throne of the queen, her clothing, and jewelry, and each item of the lavish, bejeweled services used at the sumptuous banquet.[10]

After the banquet, the nymphs lead Poliphilo to the lower courtyard where they walk through an orange grove and a series of extraordinary gardens, one made entirely of glass and gold, a second that is an aquatic labyrinth and a third made of silk and decorated with pearls and vines of gold. The glass garden, for example, is filled with pots of artificial plants. In place of real greenery, "every plant was of very pure glass, excellently [made] beyond what one could imagine or believe, intopiated boxes with the roots and stems of gold." Here is just one of many examples in which the natural and the artifactual are interchanged to the delight and stupefaction of the wandering Poliphilo.[11]

The *Hypnerotomachia Poliphili* is a literary work by an author who is enthralled by architecture, fabricated objects, and myriad specific natural species. It contains numerous detailed lists and encyclopedic descriptions of both natural and fabricated objects. Frequently, Poliphilo expresses astonishment at both kinds of objects. The examples mentioned here—the pyramid that is actually a carved-out mountain, the colossal statue of a man that groans, the fabricated horse that trembles as if alive, and the gardens made of beautifully fashioned glass, gold, silk, and pearls—each obscure or transgress the boundaries between the artifactual and the natural. The *Hypnerotomachia Poliphili* exhibits an interchangeability between natural and constructed things as it also displays a kind of descriptive exuberance in which plants, birds, and trees are described in exorbitant detail, as are architectural ruins, structures, inscriptions, and crafted objects of all kinds.

MACHINES AND MOTION IN MADRID CODEX I

Leonardo created the *Madrid Codex I*, a treatise on mechanics and the mechanical arts, between 1492 and 1497 shortly before the publication of the *Hypnerotomachia Poliphili*. It is far different from the architectural romance, but also provides evidence of the view that the natural and the artificial are entities that are closely associated with each other. The folios of *Madrid Codex I* are filled with beautiful drawings of machines and devices surrounded by detailed textual explanations concerning how they work and how they demonstrate the ways in which the natural world works. The treatise as a whole focuses on practical mechanics and the sciences of weights and motion. It treats the motions of toothed wheels, springs, clock escapement

mechanisms (what he calls *tempi*), continuous and discontinuous motions of various sorts, counterweights, chain gears, screws, pinions and wheels, endless screws, lifting devices, mills, keys and locks, and crossbows, among others. In this work and in his other writings as well, Leonardo constructs analogies of various kinds between mechanical devices and natural phenomena.[12]

He compares the mechanical and the natural early in the treatise when he equates the earth to a cannonball: "If it were possible," he writes, "to make a bombard having the earth for its ball, and because a bombard throws a ball of one *braccio* to a distance of 3 *miglia*, we can measure the distance 9,000 *braccia* which equals 9000 balls. We could therefore assume that such a bombard would throw our earth to a distance equal to that of 9000 times its diameter. Assuming this to be 7000 *miglia*, it would come to 63 thousand *miglia*."[13] What is interesting about this passage is not that Leonardo makes a multiplication mistake, but that he makes a cannonball and the earth itself interchangeable. He imagines the earth behaving in the same way as a ball shot by a bombard, and attempts to calculate the resulting distance mathematically.

Madrid Codex I contains many illustrations of machines and devices that in part are the result of Leonardo's studies of motion, but are also grounded in his practice as an engineer, painter, and sculptor. In the 1490s Leonardo's relationship with the Sforza court involved him in a system of court patronage, which he acquired primarily on the basis of his abilities as an engineer and productive artist. I suggest a model of patronage here in which the system of court patronage is mixed with a system of production and commerce. The Sforza created a court that included learned humanists and famous artisan practitioners such as Leonardo. They also strenuously involved themselves in the armaments industry and in canal building undertaken to improve transportation and agriculture primarily for commercial purposes. Court patronage, material production, and commerce were not contradictory activities, but functioned together in reciprocal support.[14]

This is the context within which Leonardo wrote *Madrid Codex I*. The folios of the codex are filled with drawings of mechanical devices and machines that illustrate not just themselves, but serve as devices for conceptualizing principles in the natural world and for thinking about how things both natural and artificial work. Leonardo is interested in how devices work in practice. He often describes their specific motions, as well as factors such as friction that cause problems. Yet he is also interested in the principles of motion.

For example, in a section that begins with the heading "Questions," he asks: "Why does the flame rushing to its [natural] place take the shape of a pyramid while water becomes round in its descent, that is, at the end of the drop?" After posing this question involving the differing shapes of two different elements as they seek their natural place, Leonardo launches into a discussion of what I would call the shape of motion of a device consisting of

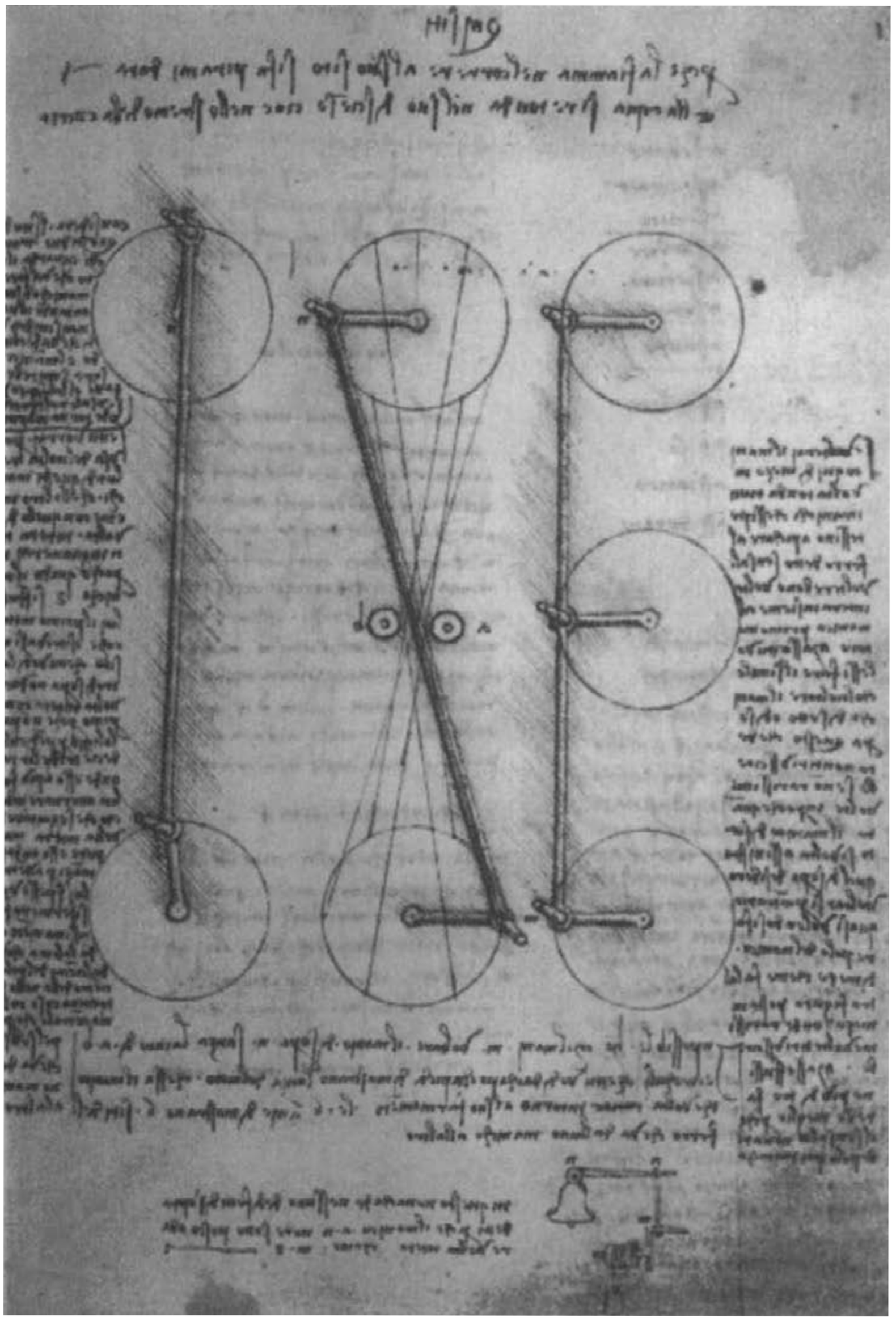

Figure 2.1 Leonardo da Vinci, *Madrid Codex I*, fol. 1r. Cranks with Connecting Rods. Courtesy of Biblioteca Nacional, Madrid.

two cranks joined by a connecting rod (Fig. 2.1). He illustrates the same device twice within a chronological time sequence, first on the left, and then in the middle after the crank has been moved. (The depiction on the far right shows a variation.) He invites his reader to consider the position of these two cranks. If you move the lower crank to the left, the upper one will go right, he says, but the length of the *sensale* or connecting rod will not permit it to go all the way around because "it could not overcome the perpendicular line that

unites the centers of their axles. Therefore, the crank will have more ability to turn back than to make a complete revolution."[15] And indeed, in a model of this device that I constructed, the top crank usually goes halfway around and then reverses itself. Occasionally it makes a full circle.

As this example shows, Leonardo's drawings are not superfluous illustrations of what he explains in the text. Rather the text concerning the motion of these crank devices would not really be comprehensible without the drawings. Text and drawings are necessary to one another. The drawings represent devices that Leonardo may have constructed and used for observation and experiment. The pages show the devices themselves, how they are made and how they work. They illustrate the particular motions of specific devices. Leonardo frequently reiterates the point that slight deviations in construction will cause major problems. Craft skill is necessary in order to construct instruments that will properly demonstrate principles of motion. Leonardo offers hundreds of close-up studies of actual local motions made by various devices in a great variety of different circumstances. The understanding of motion in the natural world, the observed motions of the devices themselves, and the visual images of those devices are closely linked.

As this page demonstrates, Leonardo's devices function on some level as observational tools. He constructs various devices and then observes and describes how they move, in what direction and how fast. It is probable that Leonardo often actually constructed, or had constructed by others, many of the devices that he draws. We know that he frequently hired German artisans to make machines and devices for him. He also mentions from time to time his own experimentation.[16] Some of the effects that he describes probably could be learned only by making the device and actually observing its motions.

For Leonardo, the study of motion entails construction, observation, and explanation using visual images. One can hypothesize that his procedure usually consisted of constructing a particular device, drawing it, moving it, and then describing and explaining its motion. He often adopts Aristotelian assumptions about motion (e.g., his remark about the flame and the water going to their natural places). Yet his mechanics are not fundamentally Aristotelian because they require constructing and then observing the motions of constructed things, thereby ignoring the Aristotelian distinction between art and nature. Neither are his mechanics Galilean, and they should not be read anachronistically in the context of Galileo's mechanics. Unlike Galileo, Leonardo usually does not analyze motion mathematically, nor does he create idealized situations that eliminate such local conditions as air resistance and friction. Leonardo creates machines and devices, and then he watches them move and describes that motion; or perhaps in some cases he does not construct the devices but draws them and imagines how they might move. It

is not uncommon for him go back and forth between the motion of a device and motions in the natural world.

For Leonardo, local motion of machines and the motion of wind, air, water, and the earth itself can be reciprocally explanatory. He is in part indebted to Archimedes and to the pseudo-Aristotelian mechanics as well as to some scholastic writings on impetus. Yet his mechanics are uniquely his own. They might be described as an observational and experimental mechanics dependent on visual representation to explain and demonstrate particular motions in a material world in which friction, air resistance, and small glitches of construction are perpetual concerns.

ALBRECHT DÜRER AND THE COMMERCE OF ART AND NATURE

The reciprocity of natural objects and images occurs in a very different sort of way in the work of Albrecht Dürer. Dürer's city of Nuremberg was an important center of trade in the empire, and he was influenced by the commercial environment in which he lived. He made two trips to Italy by accompanying the Nuremberg merchant convoy that regularly traveled to Venice. These trips were important to him both for artistic and social reasons, and he may have met Leonardo or some of his acquaintances (such as Luca Paccioli) on one of these trips. During his lifetime, Dürer used the printing press to gain a degree of economic autonomy and control over his artistic production by managing the marketing of his prints. Rather than following the customary practice of waiting for orders, he created a stock of woodcut prints and copper plate engravings. He kept his worked plates and blocks in his possession and used them whenever he needed a new supply of prints for market. At times he hired salesmen to go from city to city to sell his prints. He also sold them himself in Nuremberg. His wife, Agnes Frey, throughout her husband's productive work life functioned as his business manager and handled many of his print sales, both by selling in Nuremberg and by traveling to markets in nearby cities such as Frankfurt.[17]

Dürer's work in general was far more portable than the work of the average artist of his time. Most of his production consisted of small objects that could be carried, and bought and sold, or offered as gifts. Yet this portability was not limited to prints, as is attested by his watercolor landscapes. In 1494 before he left Nuremberg for Venice, Dürer painted two watercolors of local subjects, the *St. Johannis Kirche* and the *Wire Drawing Mill*. As Peter Strieder describes it, they are "the first known autonomous representations of identifiable localities and served to raise watercolour to the status of an independent medium, the full potential of which Dürer had grasped." Shortly thereafter, on his return from his first trip to Venice in 1495, Dürer painted

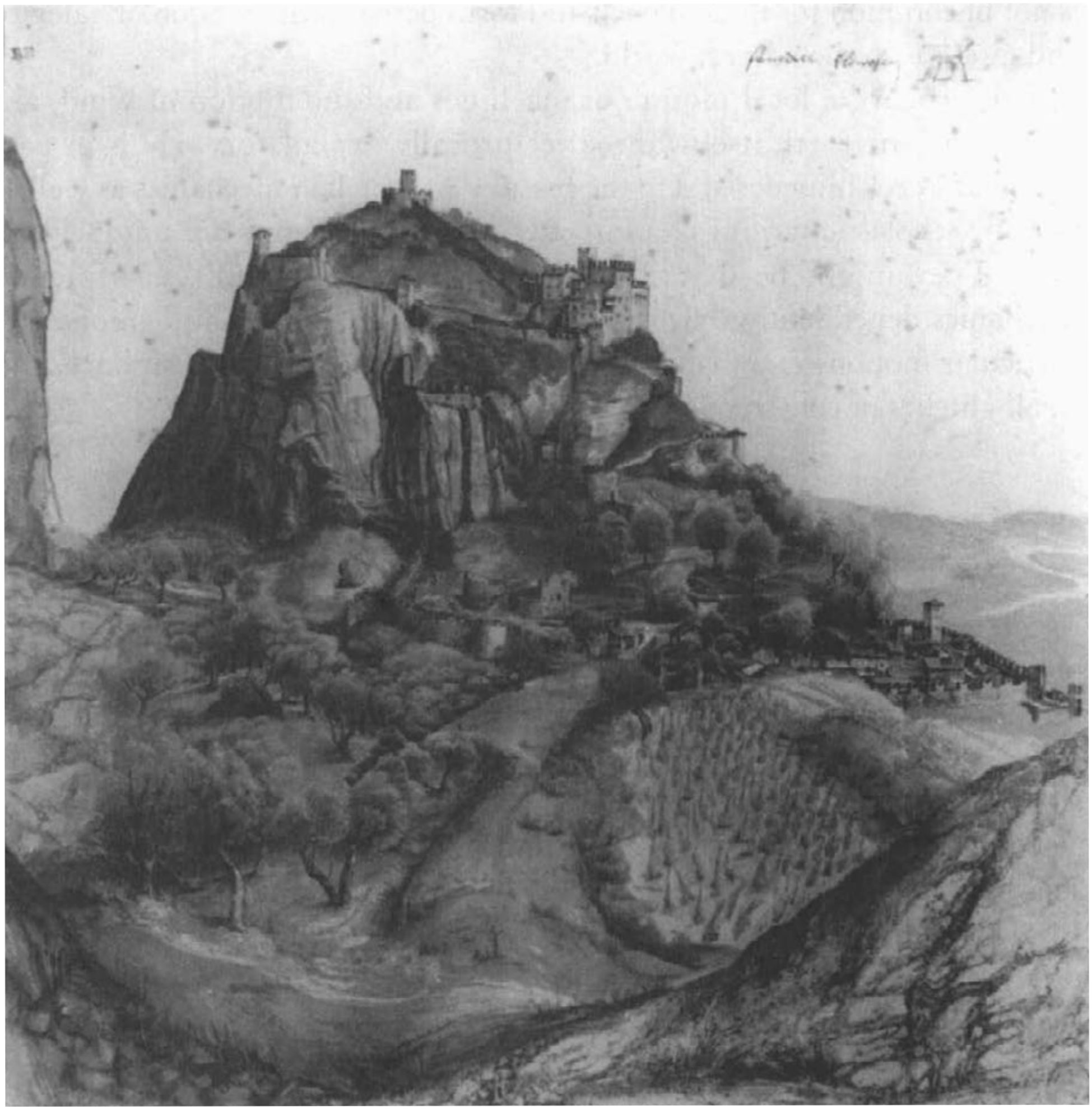

Figure 2.2 Albrecht Dürer, *View of the Val d'Arco, in the South Tyrol*, 1495. Watercolor. Louvre, Paris. Giraudon/Art Resource, New York.

watercolor views of places he passed through. An example is his painting of Arco (fig. 2.2) which combines a masterful composition with beautiful and diverse details of rocks, flora, and buildings. One could almost call it a portable view that he carried back to Nuremberg. Yet as Hermann Leber analyses in detail, it is not only a record of a view, but a carefully constructed composition. This is just one of many examples whereby Dürer created portable pieces of "nature" by means of his art; his genius for creating naturalistic representations made such paintings as his renowned hare and *The Great Piece of Turf* (fig. 2.3), the latter a wonderfully detailed painting of a grassy piece of turf, famous in his own lifetime.[18]

For Dürer objects of art and objects of nature became almost interchangeable especially as he traveled and admired and collected a great variety of

Figure 2.3 Albrecht Dürer, *The Great Piece of Turf*, 1503. Watercolor on paper. Vienna, Graphische Sammlung Albertina.
Courtesy of Albertina, Wien.

objects, natural and constructed, including paintings. This interchangeability is especially evident in his diary of a trip to the Netherlands in 1420–21, as has been pointed out by Dagmar Eichberger. For example, in the Nassau house of Margaret, he reports that he saw "the good picture that Master Hugo painted," two fine large halls, treasures everywhere in the house, "also the great bed wherein 50 men can lie." He saw further "the great stone which the storm cast down in the field near the Lord of Nassau." And finally, from the high-standing house, "a most beautiful view, at which one cannot but wonder; and I do not believe that in all the German lands the like of it exists."[19] Various treasures, a painting by Hugo van der Goes, marvels such as a huge bed and a stone, and an extraordinarily beautiful view are all remarked in the same paragraph and seem to occupy the same conceptual realm.

Dürer's delight in both natural and fabricated objects, and his careful itemization of both, resembles in some ways the detailing of specific natural and artificial objects in the *Hypnerotomachia Poliphili*. Dürer's wonderful landscapes, plants, animals, and "slices" of nature such as the *Great Turf* strikingly celebrate the ability of human artifice to create elements of the natural world. In so doing, the artist/creator closely imitates the divine Creator, just as artificial things and natural things come to resemble each other.

SERLIO AND VESALIUS

The proximity of the artificial and the natural increased through the interaction of artisanal and learned cultures in the cities and courts of Europe. Thus the influence of Serlio's treatise on the architectural orders, published in 1537, upon Vesalius's *Fabrica* on human anatomy, published in 1543, resulted in part from the proximity of the two men themselves and their shared culture. Serlio trained in a workshop as a painter, lived in the Veneto in the 1530s and associated with the painter Titian and his circle, which included both painters and learned humanists such as Pietro Aretino. Vesalius lived in Padua and Venice in the late 1530s; he was teaching anatomy at the University of Padua when he wrote his treatise. Vesalius had the illustrations for the *Fabrica* created in Titian's workshop, clearly under his own close supervision (as the level of anatomical detail makes certain). He was probably familiar with Serlio's treatise on architecture. Each man used visual representation in ways that were innovative for their respective disciplines.[20]

Serlio's book, which would eventually become part of a more extensive treatise, focuses upon five architectural styles or orders. Serlio wrote his didactic handbook for designers of buildings and others who were interested in Vitruvius and in classical building styles. Pictures appear on virtually every page and depict various parts of buildings designed in a variety of ways. One example shows pictorially and also describes three different gates. The first, called rustic work, is suitable for a country villa; the second, suitable to the Tuscan style, was seen in Trajan's Forum for a long time before it fell into ruin; the third door with "a segmental arch which is the sixth part of a circle, is a work of great strength." Serlio in this way depicts various kinds of architectural styles pertinent to particular elements of the building, many if not all from observation. He shows them to the architect who can then pick and choose various elements for his own designs. As Serlio says about his drawing of the Trajan Forum: "The two niches on either side are out of place, but I have put them here in order to demonstrate the different

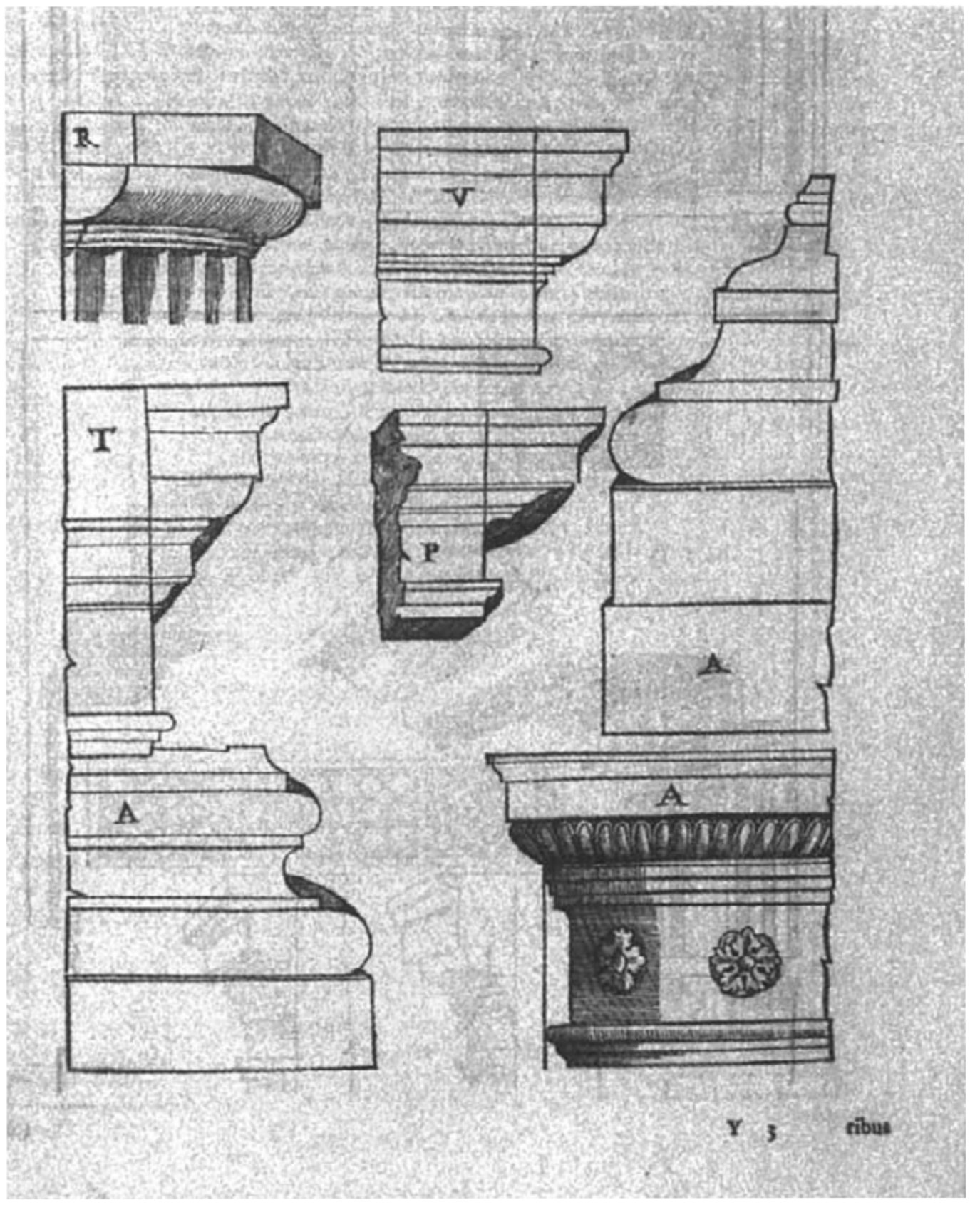

Figure 2.4 Sebastiano Serlio, *De architectura libri quinque* (Venice: Franciscus de Franciscis and Joannes Chriegher, 1569), 235. Elements of architecture. Courtesy of the Burndy Library, Dibner Institute for the History of Science and Technology, MIT.

types of niches which would suit such work, so that the judicious architect can make use of them and put them in the right place."[21]

Serlio often seems to work with Vitruvius's *De architectura* in one hand, and ancient architectural fragments and ruins in the other. For him, the discipline of architecture requires detailed study of the ancient text, careful observation of ancient structures and ruins, and depiction of those observations in the form of copious illustrations. He writes, "Because I find a great discrepancy between the buildings in Rome and other places in Italy and the writings of Vitruvius, I wanted to show some elements which, to the great pleasure of architects, can still be seen on buildings." He provides pictorial representations of various parts of different buildings that he has drawn from observation (fig. 2.4). He labels the parts of buildings with letters and identifies them. R was found outside Rome on a bridge over the Tiber. V is above a triumphal arch in Verona. T is in Rome on a Doric temple in the Tullian Prison. "The capital P was found in Pesaro with many other praise-

worthy things: its projection, although it may be large, is nevertheless very pleasing to viewers." The podium, base, and capital A are in the Forum Borarium in Rome.[22] This is a collection of architectural fragments, carefully drawn from actual examples, for the use of practicing architects and students of Vitruvius and of ancient architecture.

It is probable that Vesalius saw Serlio's book while he was working on the *Fabrica* and took some ideas from it. Serlio's architectural representations with their softly shaded renderings look very similar to some of Vesalius's carefully depicted body parts. Vesalius uses illustrations as one way of narrowing the wide gap between university medical learning and the artisanal practice of surgery. He wants to integrate the artisanal practices of the surgeon and the apothecary into the practice of medicine as a whole. He believes that he is restoring anatomy to its ancient splendor. In his view, medicine was destroyed when its various components such as surgery were broken off from it and relegated "to laymen and people with no knowledge of the disciplines that go to serve the healing art." Similarly, the art of drugs and medicines was handed over to apothecaries. Trained physicians only prescribed medicines and regimes for hidden or internal ailments. As a result, "they shamefully cast aside the foremost and most ancient limb of medicine, the limb that above all is founded . . . on the study of nature."[23]

Vesalius emphasizes that the order of books in the *Fabrica* is the same as the order that he has followed during his own dissections in the company of the eminent men of the city. "This means," he notes, "that those who were present at my dissections will have notes of what I demonstrated and will be able with greater ease to demonstrate anatomy to others." Nevertheless, Vesalius believes that his books will be "particularly useful also for those who cannot see the real thing." These individuals will be able, from Vesalius's treatise by itself, to study each part of the body, "its position, shape, size, substance, connection with other parts, use, function and many similar matters." In sum, from his illustrated treatise, they will be able to learn all the things they could study during a dissection. In a remarkable defense of virtual witnessing, Vesalius tells his readers, "pictures of all the parts are incorporated into the text of the discourse, so as virtually to set a dissected body before the eyes of students of the work of Nature."[24] Just as the architect can study the elements of the building by perusing Serlio's treatise, so the student of anatomy can study human anatomical parts by scrutinizing the illustrations and text of the *Fabrica*.

Vesalius is aware of the opinions of some "who strongly deny that even the most exquisite delineations of plants and of parts of the human body should be set before students of the natural world; they take the view that these things should be learned not from pictures, but from careful dissection and examination of actual objects." He concedes that he would never urge

students to use the pictures alone without dissecting cadavers: "Rather, I would, as Galen did, urge students of medicine by every means at my command to undertake dissections with their own hands."[25]

Nevertheless, he defends visual representation as a way of learning anatomy. "In fact," he says, "illustrations greatly assist the understanding, for they place more clearly before the eyes what the text no matter how explicitly, describes." In addition, Vesalius insists that his "pictures of the parts of the body" will give particular pleasure to those who do not have the opportunity to dissect real bodies or are too squeamish to do so.[26]

As he gets into the subject of his first book, namely bones and cartilage, Vesalius compares the function of bones to the function of certain elements in constructed things. Bone, he writes is "the hardest, the driest, the earthiest, and the coldest" of all the constituents of the human body. "God the great Creator of all things" formed its substance to be this way for good reason, "intending it to be like a foundation for the whole body; for in the fabric of the human body bones perform the same function as do walls and beams in houses, poles in tents, and keel and ribs in boats." Vesalius later describes the cartilages that form the larynx as resembling "the beams which form the framework of a country cottage before the thatch, the facings and the mud are applied. In fact, when the human bones and cartilages are stripped of their flesh and then assembled together there is no better analogy to describe them than that of the framework of a hut which has been raised but not yet finished off with branches or earth." One gathers from Vesalius's account of how to acquire a corpse and prepare a skeleton, that the usual procedure involved constructing the skeleton from pieces that had fallen apart during boiling. Even if an entire corpse was available at the outset, which was often not the case, it would fall apart during the usually necessary boiling.[27]

Vesalius's many illustrations of particular bones are labeled with numbers and letters that tie them tightly to his explanatory text. Within a discussion of the substance of bone, for example, he shows an illustration (fig. 2.5) of a humerus bone split lengthwise. He uses letters and visual indicators to show the nature of the bony substance: the little holes like pumice in the capula are marked A; the scale over these holes are marked B; C shows the outer surface of the bone, D the large hollow space along the length surrounded by the hardest bone E and F. Underneath the illustration of the humerus, Vesalius shows the navicular bone which is cut through the middle to show pumicelike bony substance. Finally, at the bottom, N is a tiny bone at the end of the toe which is cut through the middle to show it has no pumicelike holes at all. This illustration shows Vesalius's extensive cross-referencing as well. The navicular bone (a small bone of the wrist) can be seen in its entirety, he says, in figure 11 of chapter 33.[28]

Figure 2.5 Vesalius, *De humani corporis fabrica libri septem* (Basel: Ioannus Oporinus, 1555), 2. The humerus bone, split longitudinally. Courtesy of the Burndy Library, Dibner Institute for the History of Science and Technology, MIT.

The careful, beautiful drawings of the *Fabrica* and Vesalius's assiduous cataloging of the bones of each illustration by lists of descriptive identifications marked by letters and numbers make this a treatise in which visual representation and textual description are integrated in a remarkably close fashion. This integration is furthered by the fact that each time a bone or bone part is mentioned in the text, an italic indication is given in the margin showing where the illustration of the bone or part mentioned can be viewed — sometimes chapters away.

Serlio and Vitruvius each created new uses for visual representation in their respective disciplines. Both men understood the value of observing the elements of real buildings or real bodies, and both provided detailed illustrations that would allow such observation apart from actual objects by means of detailed drawings. They lived in a world in which artisanal and learned cultures were growing increasingly proximate. Each left the Veneto immediately after the publication of his respective book, attracted by courtly patronage. In 1537 Serlio moved to the court of Francis I in France, and in 1543 Vesalius moved to the court of Charles V in Spain. Each used his authorship for patronage, but each also exploited the commercial book market. Both certainly recognized that their illustrated treatises would find readers and admirers well beyond practitioners of architecture and anatomy, respectively, especially because of the attractive illustrations. As they used their illustrated treatises to acquire courtly patronage, they also had their eye on the commercial book market. In regard to that market, both complained bitterly about the theft of their writings.[29]

The sources treated here provide evidence for the pleasure taken in objects, both natural and artificial, whether it be gardens made of glass and pearls, crank machines, a landscape, a piece of turf, architectural elements, or bones. They also illustrate the increased significance of visual representation of those objects for knowledge about the world. The urban commercial economies of the sixteenth century promoted the cultural value of objects whereas hierarchical social structures increasingly were delineated by means of construction, fabrication of various sorts, and conspicuous consumption. At the same time, interactions among certain workshop-trained individuals and those from more learned and elite backgrounds became increasingly common within certain settings such as cities and courts. One aspect of learned culture, namely natural philosophy, came to be influenced by the rising cultural status of objects and their visual depiction. What is commonly understood as the increased importance of observation within the natural sciences is the result of a complex set of cultural developments having to do with the status of objects, both natural and artificial, and their visual representation.

What was deemed to be knowledge was not separate from the material/economic/social world that treasured objects. From another point of view, the cultural importance of objects was reflected in the the expansive number of visual representations of natural and mechanical objects in the sixteenth century. Those visual representations in turn functioned to explicate and validate statements about the world whether it be the motion of machine elements, architecture, or anatomy. In most of the examples presented in this essay, textual and visual material belong together and are intricately joined. Both are used to challenge traditions in at least two ways. Works such as

Madrid Codex I showed that machines were not just objects to be constructed to perform certain tasks within the mechanical arts, but objects to be visually depicted and thereby able to produce knowledge about local motion. Treatises such as Vesalius's *Fabrica* challenged the textual emphasis of the previous anatomical tradition by showing anatomical parts visually, associating them with hands-on dissections, and suggesting that visual representations could substitute for such dissections. Objects of art and objects of nature, having lost their ancient distance one from another, became more or less interchangeable instruments in the construction of knowledge.

Notes

1. For a wide-ranging study of some of the relevant issues, see David Summers, *The Judgment of Sense: Renaissance Naturalism and the Rise of Aesthetics* (Cambridge: Cambridge University Press, 1987).

2. Alan Gabbey, "Between *Ars* and *Philosophia Naturalis*: Reflections on the Historiography of Early Modern Mechanics," in *Renaissance and Revolution: Humanists, Scholars, Craftsmen and Natural Philosophers in Early Modern Europe*, ed. J. V. Field and Frank A. J. L. James (Cambridge: Cambridge University Press, 1993), 133–145, citation on 134; and for accounts of the conflict between Aristotelian and experimental approaches, see especially Peter Dear, *Discipline and Experience: The Mathematical Way in the Scientific Revolution* (Chicago: University of Chicago Press, 1995); and Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life* (Princeton, N.J.: Princeton University Press, 1985).

3. Pliny, *Natural History*, trans. H. Rackham, Loeb, (Cambridge, Mass.: Harvard University Press, Loeb, 1952) 9: xxxv. xxxvi. 65–66 (308–311); and see J. J. Pollitt, *The Ancient View of Greek Art: Criticism, History, and Terminology* (New Haven: Yale University Press, 1974), 63–64.

4. For an account of traditional natural philosophy and its transformations, see William A. Wallace, "Traditional Natural Philosophy," in *The Cambridge History of Renaissance Philosophy*, ed. Charles B. Schmitt et al. (Cambridge: Cambridge University Press, 1988), 201–235.

5. For an introduction to this large subject, see especially, Richard A. Goldthwaite, *Wealth and the Demand for Art in Italy, 1300–1600* (Baltimore: Johns Hopkins University Press, 1993); Lisa Jardine, *Worldly Goods: A New History of the Renaissance* (New York: Doubleday, 1996); Pamela O. Long, "Power, Patronage, and the Authorship of *Ars*: From Mechanical Know-How to Mechanical Knowledge in the Last Scribal Age," *Isis* 88 (March 1997): 1–41; and Randolph Starn and Loren Partridge, *Arts of Power: Three Halls of State in Italy, 1300–1600* (Berkeley and Los Angeles: University of California Press, 1992).

6. Long, "Power, Patronage, and the Authorship of Ars"; and Pamela O. Long, *Openness, Secrecy, Authorship: Technical Arts and the Culture of Knowledge from Antiquity to the Renaissance* (Baltimore: Johns Hopkins University Press, 2001).

7. Francesco Colonna, *Hypnerotomachia Poliphili*, ed. Giovanni Pozzi and Lucia A. Ciapponi, 2 vols. (Padua: Editrice Antenore, 1984 [reprint, 1964]); Leonardo da Vinci, *The Madrid Codices*, 5 vols., Vol. 1: *Facsimile Edition of Codex Madrid I*, and Vol. 4: *Transcription and Translation of Codex Madrid I*, trans. Ladislao Reti (New York: McGraw-Hill, 1974); Sebastiano Serlio, *On Architecture*, Vol. 1: *Books I–V of 'Tutte L'opere d'architettura et prospetiva*, trans. with

introduction and commentary by Vaughan Hart and Peter Hicks (New Haven, Conn.: Yale University Press, 1996); and Andreas Vesalius, *On the Fabric of the Human Body: A Translation of 'De Humani Corporis Fabrica Libri Septem*, Book 1: *The Bones and Cartilages*, trans. William Frank Richardson and John Burd Carman (San Francisco, Calif.: Norman Publishing, 1998).

8. A lengthy romance, written in a highly Latinized Italian, it was the first illustrated book and the first vernacular book to be published by the Aldine press. Colonna, *Hypnerotomachia Poliphili*, ed. Pozzi and Ciapponi. See also Maria T. Casella and Giovanni Pozzi, *Francesco Colonna: biografia e opere*, 2 vols. (Padua: Editrice Antenore, 1959), a biography of the Dominican monk of the Venetian monastery of SS. Giovanni e Paolo, Francesco Colonna (1433/34–1527) who is the probable author of the work. The recent claim that the author was Alberti does not seem convincing to me. See Liane Lefaivre, *Leon Battista Alberti's Hypnerotomachia Poliphili: Re-Cognizing the Architectural Body in the Early Italian Renaissance* (Cambridge: MIT Press, 1997).

9. Colonna, *Hypnerotomachia*, 19–28. ("intestini, nervi et ossa, venej musculi et pulpamento.")

10. Ibid., 34, ("vedevasi quasi il tremulare degli sui pulpamenti, et più vivo che fincto") and 53–95.

11. Ibid., 112–123, citation on 116, ("in loco di virentia, omni pianta era di purgatissimo vitro, egregiamente oltra quello che se pole imaginare et credere, intopiati buxi cum gli stirpi d'oro").

12. Leonardo, *Madrid Codices*, Vol. 1, f. 9r., vol. 4, 24–25 (springs, clock escapements, continuous and discontinuous motions); vol. 1, f. 10 r., Vol. 4, 27–28 (chain gears); Vol. 1, f. 15 r., Vol. 4, 39–40 (screws); vol. 1, f. 19 r., Vol. 4, 47–48 (endless screws); and Vol. 1, f. 46 v., and Vol. 4, 89–90 (mills).

13. Ibid., Vol. 1, f. 0 r., Vol. 4, 2, ("Se possibile fussi fare una bonbarda, che 'l mondo fussi sua ballotta, e che sicome una bonbarda gitta una balotta d'un braccio 3 miglia, che si pò misurare il tal corso 9000 braccia, cioè 9 mila ballotte. Noi possiamo adunque dire, che tal bonbarda gitterebbe il nostro mondo novemila volte le grandeza del diamitro d' esso mondo distante da ssè. [Sare]bono a settemila miglia per monda [sic], sarebono 63 migliara di miglia.")

14. For the Sforza court, see Franco Catalano, *Francesco Sforza* (Milan: dall'Oglio Editore, 1983); Giorgio Chittolini, ed. *Gli Sforza, la chiesa lombardia, la corte di Roma: Strutture e pratiche beneficiarie nel ducato di Milano (1450–1535)* (Naples: Liguori, 1989); Gary Ianziti, *Humanistic Historiography under the Sforzas: Politics and Propaganda in Fifteenth-Century Milan* (Oxford: Clarendon Press, 1988); Evelyn S. Welch, *Art and Authority in Renaissance Milan* (New Haven, Conn.: Yale University Press, 1996); and Gregory Lubkin, *A Renaissance Court: Milan under Galeazzo Maria Sforza* (Berkeley and Los Angeles: University of California Press, 1994). For Milanese canal building, see William Barclay Parsons, *Engineers and Engineering in the Renaissance* (Cambridge: MIT Press, 1968), 367–419.

15. Leonardo, *Madrid Codices*, Vol. 1, f. 1 r, Vol. 4, 3–4.

16. Ibid., Vol. 3, 40–41 for Leonardo's references to the various German artisans that he hired; and for explicit references to experiments, Vol. 1, ff. 77 r., 78 r., 122 v., and Vol. 4, 179–180, 183–184, 325–366.

17. For recent Dürer studies and discussion of the importance of Nuremberg for his work, see especially Jane Campbell Hutchison, *Albrecht Dürer: A Biography* (Princeton, N.J.: Princeton University Press, 1990), 14, 23–26, 57–66, and 78–83 (for his travels and the sale of his prints); Dagmar Eichberger and Charles Zika, ed., *Dürer and his Culture* (Cambridge: Cambridge University Press, 1998); and Peter Streider, "Dürer. (1) Albrecht Dürer," *The Dictionary of Art*, ed. Jane Turner (New York: Grove Dictionaries, 1996), Vol. 9, 427–445.

18. Strieder, "Dürer," 429; and Hermann Leber, *Albrecht Dürers Landschaftsaqarelle: Topographie und Genese* (Hildesheim: Georg Olms Verlag, 1988).

19. Dagmar Eichberger, "*Naturalia* and *Artefacta*: Dürer's Nature Drawings and Early Collecting," in *Dürer and his Culture*, ed. Dagmar Eichberger and Charles Zika, 13–37; and Albrecht Dürer, *Schriftlicher Nachlass*, ed. Hans Rupprich, 3 vols. (Berlin: Deutscher Verein für Kunstwissenschaft, 1956–69), Vol. 1, 146–202. I cite the translation in Albrecht Dürer, *Diary of His Journey to the Netherlands, 1520–1521*, trans. Frank Conway (Greenwich, Conn.: New York Graphic Society, 1971), 64–65.

20. Serlio, *On Architecture*, xix; and Vesalius, *On the Fabric*. My comparison of the two works takes up a suggestion by Vaughan Hart and Peter Hicks that Serlio's treatise bears notable similarities to Vesalius's *Fabrica*.

21. Serlio, *On Architecture*, 266–269.

22. Ibid., 286–287.

23. Vesalius, *On the Fabric*, "To King Charles V," xlvii–xlix.

24. Ibid., liv–lv.

25. Ibid., lvi. The reference is to Galen, *Procedures* 2:1.

26. Vesalius, *On the Fabric*, lvi.

27. Ibid., and 8 and (for finding and preparing bodies) 370–384.

28. Ibid., 4.

29. Serlio, *On Architecture*, xi–xxxi; and Vesalius, *On the Fabric*, xviii–xxi.

Mirroring the World

Sea Charts, Navigation, and Territorial Claims in Sixteenth-Century Spain

ALISON SANDMAN

In sixteenth-century Spain, navigation and cartography were critical industries. Commerce with the New World formed the basis of many fortunes and the hopes for many more. But it was also crucial for the survival of the fledgling Spanish colonies and the interests of the government, which carefully regulated the pilots who guided the ships across the ocean and the charts they used to navigate. Not least among their functions, the charts used by the pilots served as evidence in the ongoing disputes between Spain and Portugal about ownership of territories in the Indies. The tension between the two roles of charts—as navigational tools for the pilots of merchant ships, and as political tools of diplomats in territorial disputes—catalyzed several important changes in early modern Spain. As experts debated the uses of charts in the first half of the sixteenth century, their arguments crystallized ideas about the proper ways of representing the world in a sea chart and the value of systematic theoretical knowledge in navigation.

This chapter uses debates about sea charts as the lens through which to view changing ideas about representations of the world and their links to controversies about the utility of theoretical knowledge. While the practical culture of navigation was shaped by the commercial requirements of the merchants who provided cargo for the ships, and proved adequate to their needs, the territorial implications of sea charts took the debate out of the realm of commerce and brought it into that of imperial politics. This political importance brought new people into the field, cosmographers with closer ties to the royal court than to the pilots or the merchants. Expert in astronomy, geography, and hydrography, these cosmographers tried to reform navigation, focusing on general and systematic knowledge in place of local craft knowledge.[1] They used the newfound official attention to sea charts as a lever to implement their reforms.

Unfortunately, between losses at sea and the routine destruction of outdated charts, no examples remain of charts used at sea. We are left with a few of the pilots' own notes and sketched charts, and with presentation copies of charts that probably match, more or less, those sold to the pilots.[2] Fortunately, a large variety of sixteenth-century texts survive that chronicle debates about sea charts both in Seville and at the royal court.[3] These texts contain most of the available information about the use of charts in the sixteenth century, and so are an invaluable source for ideas about the proper representation of nature.

Since Seville was the center for travel to the Indies, the debates there focused on the use of charts in navigation, and, more narrowly, on what charts should be sold to pilots. These debates took place within the *Casa de la Contratación* (House of Trade), which had been founded in 1503 to regulate trade with the New World, including the actions of the pilots.[4] In 1523 the growing importance of the new territories led the crown to create a new council, based at court, to take over policy decisions relating to the Indies. As soon as debates about charts were referred to this council, however, it became clear that more was at issue than which charts were most useful at sea. Since 1494, when the Treaty of Tordesillas set the boundary between Spanish and Portuguese overseas territories as a line of longitude, east-west distance had been crucial to territorial claims and disputes. As longitude could not be reliably measured at sea, however, it was not particularly important to the pilots when navigating. Pilots customarily did their best to estimate distance traveled, using their knowledge of currents and winds and the characteristics of the ship. They then set an especially careful watch when they thought they were approaching land. Their craft did not need an accurate representation of longitude on sea charts, which mattered more to diplomats than to navigators. Indeed the Council of the Indies was attuned to precisely such diplomatic concerns.

Abandoning local disputes in Seville, a handful of reforming cosmographers, whom I call theory proponents to distinguish them from an even smaller group of more traditional cosmographers, took their case directly to the council and the king. They used the evidentiary potential of charts to win support for their view that the key to navigation was the ability to accurately locate both the ship itself and the ports to be reached in terms of a coordinate grid of latitude and longitude. Since the only methods to do this involved astronomical observations, they thought navigation necessarily an application of general rules, and as such a science.[5] Though the councillors never ruled on how pilots should navigate, in supporting the charts of the theory proponents they also supported the latter's efforts at reform, undercutting the craft culture of the pilots.

The arguments about the construction and use of the official pattern chart illustrate the key issues in the case: the representation of nature, the

disputed uses of that representation, and the ways in which these problems were connected to debates about the nature of navigation and the importance of general knowledge.[6] During the sixteenth century the theory proponents made a concerted effort to gain control of both the institutions of navigation and the practices of the pilots while at sea. The creation of a new pattern chart was central to their endeavors. The royal attention that surrounded the creation of a new pattern chart not only enticed new cosmographers into navigation, increasing the influence of the theory proponents, but also provided them with an audience that was more receptive to their claims than were pilots and merchants, and one that possessed sufficient authority to demand changes.

CONSTRUCTING THE PADRÓN REAL: WHO SHOULD MAKE A CHART

All charts used at sea were supposed to match a central exemplar, known as the *padrón real*, or royal pattern chart.[7] In 1526, after failed boundary talks with Portugal had underscored the inadequacy of the available charts, the Council of the Indies decided there was need for a new pattern chart. In the absence of the pilot major, the person at the Casa de la Contratación in charge of charts and instruments, they entrusted the revision to Hernando Colón, the younger son of Christopher Columbus, ordering him to make both a sea chart and a world map.[8] As a cosmographer and bibliophile with some diplomatic experience, Colón had long been involved in the conflicts surrounding Spain's territorial claims in the Indies.[9] Colón chose as an assistant Alonso de Chaves, arranging for him to be appointed as one of the royal cosmographers at the Casa.[10] Though little is known of Chaves's early life or training, by 1526 he was working as a cosmographer in Seville, and he remained a steadfast supporter of all attempts to increase the pilots' level of education, especially their knowledge of astronomy.[11] With help from Chaves, Colón began to compile a book filled with information from returning pilots, who were ordered to keep daily records while at sea.[12] Though the book eventually contained statements from more than 150 pilots, the attempt to make a new pattern chart seems to have been abandoned unfinished.[13]

Almost ten years later, in 1535, the Council of the Indies sent a letter to Colón in Seville, asking him about the status of the chart and ordering him to finish it as soon as possible.[14] The same letter also empowered the Casa de la Contratación officials to order all of the pilots and cosmographers in Seville to help him finish it. At this point, however, Colón was no longer active in navigation, and without his support Chaves's authority had been much diminished, especially after the return of the pilot major, Sebastian Cabot. Cabot took over most of the cosmographical work in Seville, helped by his friend and ally Diego

Gutiérrez, who made most of the charts used at sea.[15] Both men were allies of the pilots, and resolutely opposed the reforms of the theory proponents.

Cabot had been pilot major since 1518, shortly after Charles I (later Emperor Charles V) came to power, but had spent the years between 1526 and 1530 on a voyage of exploration.[16] He had long identified himself with the pilots and emphasized the importance of practical experience. In fact, he was first hired away from England on the basis of his claims to experience in the northern route to the New World.[17] He himself had little or no cosmographical training and did not place particular importance on the education of the pilots, though as pilot major he was supposed to be in charge of their training. In 1526, Cabot was sent to reinforce the Spanish presence in the Spice Islands, and his absence gave the theory proponents their opportunity to impose reforms. Cabot's voyage was striking for its lack of success, and on his return he was sentenced to fines and several years of exile in North Africa. The sentence seems never to have been carried out, and soon he was again serving as pilot major and struggling to regain his former authority.[18]

Over the next several years Cabot worked to counter the influence of Chaves and Colón, appealing changes in the rules on licensing exams that had weakened the office of pilot major during his absence, and supporting the appointment of Gutiérrez, who shared his emphasis on experience.[19] As with Chaves, little is known about Gutiérrez's early life. He first appeared in the Casa records with an application to be appointed cosmographer, supported by a petition signed by Cabot and a long list of pilots.[20] Though he won the appointment in 1534, his salary was negligible, and the bulk of his income came from selling charts and instruments to the pilots and tutoring them for the licensing exam. He earned enough from such sources to set up his son Sancho as a shipowner as well as a cosmographer.[21]

By 1535, when Colón was ordered to finish the padrón, Cabot and Gutiérrez were firmly in charge. This changed, however, when three new cosmographers responded to the crown's call to help revise the pattern chart, as they were predisposed by training and social status to ally themselves with Chaves. The first of the new cosmographers, Francisco Falero (or Faleiro), had come to Spain from Portugal in 1518 to help organize Magellan's voyage.[22] He did not go on the voyage, but remained in Spain, helping as called upon with various projects. He confirmed his credentials as a learned cosmographer in 1535 with the publication of a commentary on Sacrobosco's *Sphere* and its application to navigation.[23] Though he was certainly not new either to cosmography or to Seville, Falero seems to have stayed out of local politics whenever possible.

The others who helped revise the pattern chart were new to the profession. Alonso de Santa Cruz was just beginning to make a reputation for himself as a cosmographer. He brought to the project an abiding mistrust of

Cabot, gained while sailing under him on his ill-fated voyage as an agent of the investors. Santa Cruz had become interested in cosmography during the voyage, and spent much of the rest of his life writing books on the subject and devising instruments and methods for finding longitude at sea.[24] Pedro Mexía, a local dignitary with some reputation as a humanist and an astrologer, also joined the revision, and in 1537 the council rewarded him with a post as cosmographer.[25] The success of his literary endeavors soon propelled him to more prestigious positions, but even at this point in his career he added weight to the idea of the cosmographer as educated expert.

The addition of the new cosmographers to the *padrón real* project shifted the balance toward people with a more scholarly and theoretical orientation; though Santa Cruz and Falero both had experience at sea, they presented themselves as knowledgeable cosmographers rather than as experienced pilots. The new cosmographers also had closer ties to the royal court than did Chaves or Gutiérrez: Falero had been employed at various tasks since 1519, Santa Cruz held an appointment in the royal entourage to supplement his income in the Casa, and Mexía was later appointed as royal chronicler.[26] Though the three by no means presented a united front, all tended to ally themselves with Chaves rather than with Cabot and Gutiérrez.

With such a large and diverse group, constructing the *padrón* was far from easy, especially as the committee members could not agree on how to reconcile the pilots' reports. The six men spent more than a year in contentious meetings in the house allocated to Juan Suárez de Carbajal, the visiting inspector from the Council of the Indies who was overseeing the project. Finally Suárez de Carbajal ordered them to vote on each point at issue and abide by the majority decision. When they objected, he argued that panels of judges routinely decided legal cases by vote.[27] Why should mapmaking be different? This ruling pleased no one, but it did allow them to finish.[28]

Santa Cruz's objections to the proceedings were so strong that he abandoned the project. Before the chart was even finished he left Seville to complain to the Council of the Indies. He later claimed that because of his report the councillors held the chart in little esteem, though this is hard to reconcile with their subsequent approval of the chart.[29] In any case, his travels were not in vain, for Santa Cruz returned from court with increased authority over cosmographical matters in Seville and with permission to gather the information he thought necessary to revise the *padrón real*.[30] Cabot fought this increase in Santa Cruz's authority, and the issue of their relative precedence was never satisfactorily resolved, though Santa Cruz began to spend more time at court and traveling instead of in Seville.[31] By the end of the 1540s he had returned to Seville but was shut up in his house, writing feverishly but participating little in the cosmographical work of the Casa.[32] Despite all protests, the chart approved by Suárez de Carbajal became the

official pattern chart and served as the basis both for making sea charts for pilots and for subsequent revisions.

OBTAINING RELIABLE INFORMATION

Subsequent events, however, revealed more problems in the process, as Cabot, Gutiérrez, and Falero all joined Santa Cruz in disavowing the chart. The ensuing discussions and justifications show the deep disagreements not only about who should make the chart, but also about how to get reliable information and how to decide which information to trust. The pilots' supporters were outvoted, while the theory proponents argued among themselves about whose expertise counted and whether the problems were sufficient to justify junking the chart.

Everyone involved agreed that the pilots were indispensable, for they were often the only available source of information. Access to reports from pilots was considered crucial for anyone interested in correcting charts, so crucial that Santa Cruz, on his return from court, fought the Casa officials for the right to hear reports from returning pilots in a timely fashion.[33] There was also general agreement that oral testimony from experienced pilots could usefully supplement the statements collected over a period of time, so that it made sense to call the pilots to testify at meetings, as indeed happened.[34] Clearly, no one thought the pilots could be ignored.

At the same time, however, most of the cosmographers did not trust the reports of the pilots. As one pointed out in an anonymous pamphlet, when three pilots on the same ship could calculate their position variously as 100 leagues from land, 45 leagues from land, and sailing on dry land, there was clearly some problem in their observations, and thus some role for cosmographers.[35] The author was arguing that since the astronomy behind the methods was unimpeachable, the problems must stem either from the instruments or from the pilots' use of them. Though the example was surely apocryphal, its use illustrates the contempt that many cosmographers felt for the reports of the pilots.

Indeed, Falero gave a masterful summary of the problems of relying on such reports.[36] Most pilots, he said, located positions using compass bearings rather than latitudes. These compass bearings were frequently inaccurate, because many failed to account for magnetic declination, the amount by which the north shown on the compass was offset from geographic north. Those who did correct their compasses for declination often made the wrong adjustment, compounding the error. Furthermore, the few pilots who did determine location by latitude were rarely accurate enough for their observations to be useful. Falero concluded that since the charts made

from pilots' reports were based on shaky foundations, it would be best to start anew.

Falero's proposal for reforming the charts involved nothing less than a new survey of the West Indies. He suggested that the survey be done by skilled pilots, all taking frequent latitude observations, using new and accurate instruments, and adjusting their compasses for declination at frequent intervals. He also wanted the pilots to keep a daily written record of their observations, remarking that it would be impossible to give a full report from memory. This plan essentially involved making the pilots behave as cosmographers, and in fact he went on to suggest that if possible a cosmographer should be sent to oversee the survey. Falero's proposal shows how deeply he distrusted the reports and methods of the pilots.

Santa Cruz, on the other hand, felt that the available reports could be made to serve if the pilots could only work without interference from biased cosmographers. He complained bitterly, however, about the qualifications of the other cosmographers involved in the project. He objected that his vote was held equal with that of Pedro Mexía, "who at that time had never in his entire life seen a sea chart nor understood that language," and of Francisco Falero, "who only knew a little about the sphere and judicial astrology," but each "presumed to give his opinion, just like one who understood better," while despite his position Cabot could not be relied on. According to Santa Cruz, he himself was often overruled to the great detriment of the chart, and in sum the whole procedure had made laughingstocks of all the cosmographers involved. As an alternative, he suggested that the pilots be taken one by one into a room with no cosmographers present and asked to point out any flaws in the chart. If each pilot was carefully questioned under oath about where he was licensed to go as pilot, where he had been, and what was good and bad about the chart as it was, they could soon have a chart much better than any that had yet been produced. Santa Cruz never said, however, what should be done if the pilots disagreed. Instead he seemed to assume that the combination of oaths and detailed questioning would yield accurate reports, and hence remove all disagreements.[37]

Chaves and Mexía were working from a similar assumption, but thought that this degree of consensus had already been obtained for most areas of the chart. They argued that the flaws in the pattern chart had been greatly exaggerated, and that most of the problems were in newly discovered areas and so would disappear when there were more reports.[38] They did not, however, solve the problem of disputed testimony. Chaves said that one reliable statement for each area would be enough, provided it was from a man "who knew and had seen what he said," but it is not clear whether he thought any of the pilots reached this standard. Pedro de Medina, who had arrived in Seville only after the chart was completed, took his critique further. The

problem with relying on reports from pilots, he said, was that they risked introducing errors rather than fixing them, which was a "very great damage and danger to the seafarers, from the statement of just one person to lose the truth and the statements of many."[39] But he gave no indication of how to tell which statements were reliable.

Cabot and Gutiérrez blamed not the reports of the pilots, but the lack of eyewitness experience among the members of the committee. Gutiérrez did not object to the idea of voting, but thought the wrong people were being polled. "None of those who were there," he said, "had been in the Indies, nor was a sailor, nor had seen the coasts, islands and bays, except only the pilot major who was a sailor and understood the art of navigation." Though this comment discounts Santa Cruz's time at sea, Santa Cruz had shipped as an agent for investors in the voyage rather than as a pilot or sailor. The pilots themselves, Gutiérrez complained, who "knew by the sight of their eyes how the coasts ran and in what latitudes they lay," were completely disenfranchised by the procedures.[40] Cabot used this same argument as a reason to repudiate the finished chart, claiming that he signed only under pressure, a claim the theory proponents indignantly denied.[41]

In fact a group of pilots later rejected the pattern chart on the grounds that experience at sea was crucial to making good charts. A statement signed by more than fifty pilots complained that "it is a harsh thing that we have to navigate by charts made according to the padrón real, which was made by people who have not sailed, nor understand the art of navigation, nor have experience in it, nor have seen the lands or the coasts, bays and islands."[42] But protest as they might, the pilots did not have a vote.

This struggle over whose testimony should be considered reveals a fundamental divide between the theory proponents and their opponents. The pilots thought the most important criterion was having seen the lands in question, and so having a knowledge base to reject inaccurate reports. The theory proponents, however, distrusted the ability of pilots to be adequate witnesses. Though all agreed that the pilots needed to bring back information on the exact locations of places, the theory proponents thought this should be based on astronomical observations, and so distrusted reports based on other methods. The pilots, however, determined locations not from such cosmographical methods, but instead from the compass bearings and distances between places. Since these were deduced from estimates of the course the ship made good and the average speed, the pilots' reports were closely dependent on their knowledge of seamanship and local conditions, knowledge that was impossible without eyewitness experience.

Thus, though the theory proponents did not like having to rely on the pilots' statements about position, the issues in this instance were methods and type of evidence rather than the pilots' credibility per se.[43] Since, how-

ever, the pilots' fallibility as witnesses to the positions of lands was central to the theory proponents' claims for authority, they had little incentive to compromise. Furthermore, as is clear from Cabot's having rejected the *padrón real* on the grounds that the pilots were not consulted, the issue of whose testimony was important in making the chart was in practice inextricable from the question of who got to judge if the resulting chart was adequate, and on this issue the theory proponents certainly did not want to yield to the pilots.

TWO EQUATORS AND FOUR POLES: INTERPRETING CHARTS AND CONTROLLING NAVIGATION

The disagreement between the theory proponents and the pilots, Cabot, and Gutiérrez went well beyond a struggle over different methods of determining position and the relative importance of eyewitness testimony. More fundamentally, they disagreed about the relationship between a chart and the world it represented, and what made a chart useful or true. A few years after the construction of the *padrón*, a new cosmographer's bid to enter the market reopened the issue of which charts the pilots should use. Though by royal decree all charts sold to the pilots were supposed to be exact copies of the pattern chart, Cabot and Gutiérrez ignored the *padrón* and instead sold charts that were more popular with the pilots.

This practice was challenged by the new cosmographer, Pedro de Medina, who arrived in Seville in 1538 and tried to establish himself selling charts and tutoring pilots.[44] Though armed with a royal license to make and sell charts and instruments which he had obtained during a stay in court, Medina met with consistent obstruction from Cabot, and had trouble even gaining access to the *padrón real*.[45] Medina's problems may have been increased by the speculation that his presence was intended to act as a check on Cabot's power, since during the same period the sons of Medina's chief rival, Diego Gutiérrez, opened workshops with Cabot's support and without any apparent need to be licensed.[46]

Cabot's support, however, would not have been sufficient to guarantee a good living selling charts, for the charts also had to be acceptable to the pilots. Cabot and Gutiérrez maintained their effective monopoly through the early 1540s, despite Medina's best efforts, in large part by being extremely responsive to the desires of the pilots. Medina and the other theory proponents, on the other hand, thought that they knew which charts were best, and wanted to force that judgment on the pilots. Since the intensive regulation of charts in effect made the court (as regulator) another crucial client to be satisfied, the theory proponents seem to have hoped that

court approval would overcome the reluctance of the pilots, and so create a market for charts matching the pattern chart.

Thus when Cabot and Gutiérrez tried to block Medina's entry into the market by denying him access to the *padrón real*, Medina sued for access both in Seville and at court. In the meantime, he began to study the charts sold to the pilots by other makers. When Medina got access to the pattern chart, he discovered that the charts in common use were a novel design by Gutiérrez, rather than being based on the *padrón* as the law required. He then redoubled his efforts, beginning legal proceedings that would drag on for several years.[47] With the support of other theory proponents in Seville, Medina argued that the charts preferred by the pilots were unsafe and unusable because they were false, and, being false, didn't allow the pilots to use proper (i.e., astronomical) methods of navigation. He insisted that the only solution was for all pilots to use charts based on the *padrón real*.

Gutiérrez's charts used two incompatible latitude scales in an attempt to reconcile the observed latitudes of specific places with the compass bearings between them (fig. 3.1). The problem was magnetic declination. A pilot sailing westward using an uncorrected compass would travel farther south than he thought, by an amount that increased as he moved farther west in the Atlantic. By the time he reached the New World he would be about 3 degrees further south than expected. The solution adopted by Gutiérrez was to add a second latitude scale, offset from the first by these same 3 degrees (fig. 3.2). In this way, the chart could still show the customary compass bearings between places, the ones that the pilots were accustomed to using. But by charting latitudes in the Old World on one scale, and latitudes in the New World on the other, he could put places in their correct latitudes without changing the compass bearings at all. On his chart a ship could sail due west by the compass and yet wind up in a different latitude, precisely as the pilots did. Though his charts didn't really reconcile the two sorts of information—latitude and compass bearing—Gutiérrez did find a way to represent both systems at the same time.[48]

The theory proponents objected to this makeshift solution. They claimed that to give a chart two incompatible latitude scales also implied two North Poles, two equators, and other impossibilities, and thus "destroyed and falsified the arts and sciences, principally astronomy, geometry and cosmography."[49] In his unpublished textbook on navigation, written at about this time, Chaves compared a sea chart to "a mirror, in which is represented the image of the world in its absence," showing the "true description and true location and forms of all its particularities."[50] A mirror of the world could not portray poles or equators that didn't exist.

The theory proponents also objected in no uncertain terms to any attempt to modify the representation of the world, even to make the charts more use-

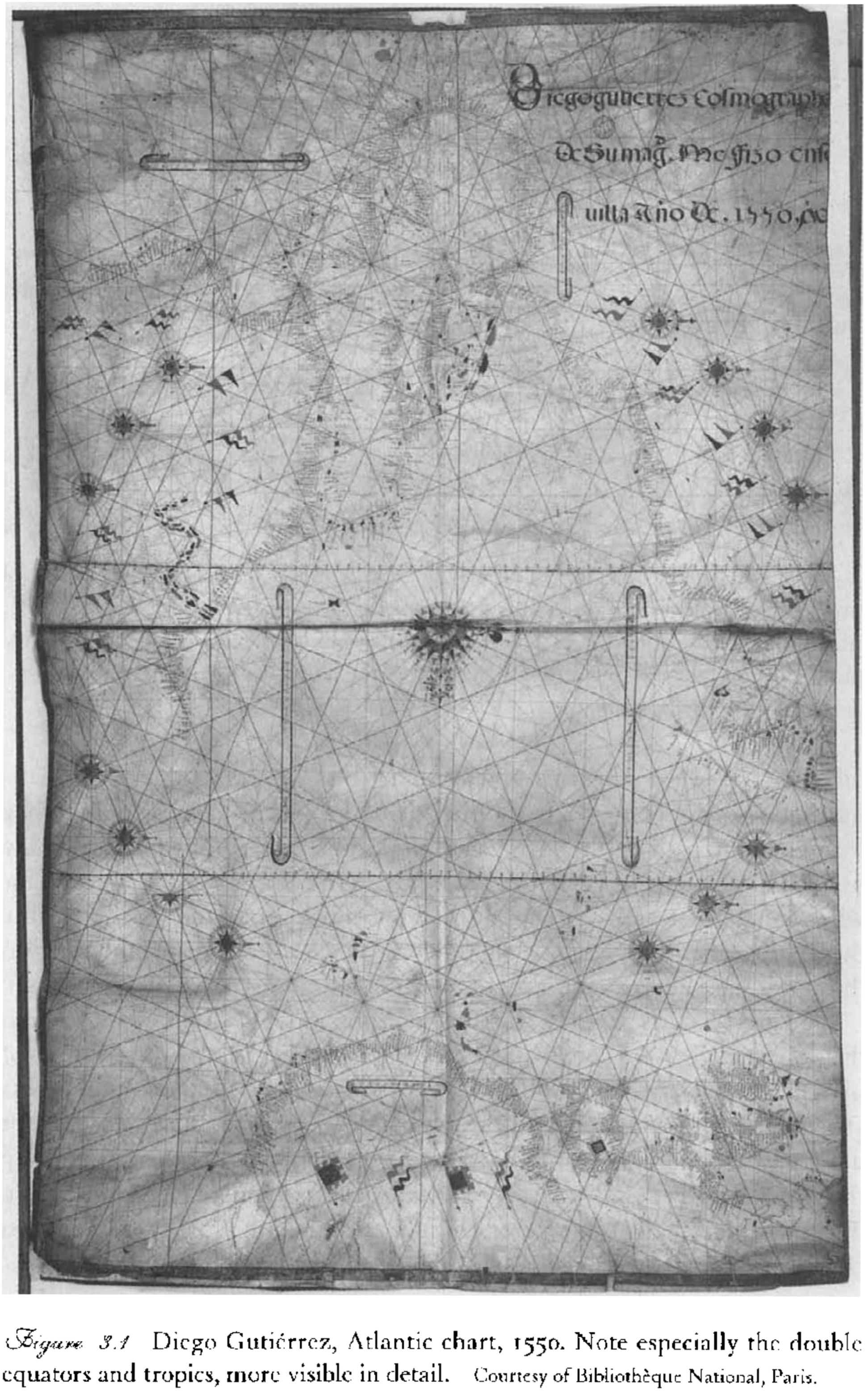

Figure 3.1 Diego Gutiérrez, Atlantic chart, 1550. Note especially the double equators and tropics, more visible in detail. Courtesy of Bibliothèque National, Paris.

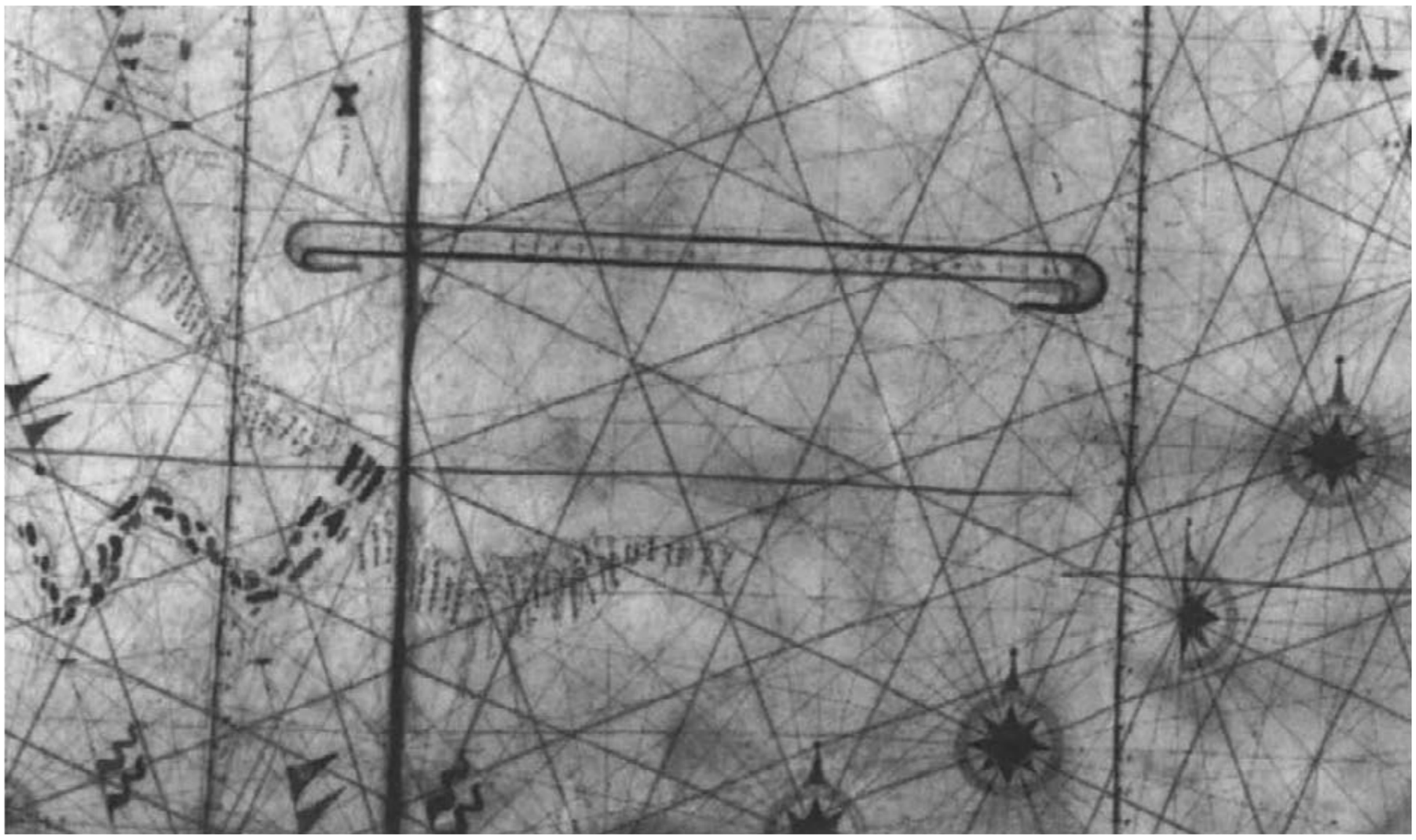

Figure 3.2 Detail from Diego Gutiérrez's 1550 Atlantic chart, showing the double latitude scales. The river to the left is the Amazon. Note the two different lines representing the equator, one for each lattitude scale. The discrepancy between the two equators is most clearly seen at the lower end of the latitude scale on the right.
Courtesy of Bibliothèque National, Paris.

ful. Chaves argued that it was better to teach the pilots to navigate by latitude than to distort the charts, adding that "it is more appropriate that they search for the path on the earth, than to put the earth in the path that they use when it isn't there."[51] Medina compared Gutiérrez's solution to a doctor who treats a man with one arm dislocated by dislocating the other.[52] All the theory proponents agreed that there was no excuse for putting anything on the chart that had no counterpart in nature.

The pilots completely rejected this interpretation of the charts. For them the double scale was a convenience that allowed them to find the latitudes of places, not a claim about the existence of two equators. Several pilots affirmed that they understood the two scales to be one and the same, but drawn as two to put the lands in the right relation to each other.[53] In taking the two equators literally, they claimed, the cosmographers missed the point. The theory proponents, however, did not trust the pilots' opinion of the sea charts, saying that they spoke with the "common voice" and were insufficiently educated to be able to judge.[54]

This was not simply a fight about the propriety of different types of representation, for underlying the debate about which charts should be used was a long-standing disagreement about how pilots should navigate. The theory proponents first became involved in navigation with the appointment

of Colón to revise the *padrón* in 1526. From that time on, they had tried to change the way in which the pilots navigated by emphasizing the importance of astronomical methods of navigation. Soon after Colón was asked to revise the *padrón* in 1526, he was appointed as acting pilot major during Cabot's absence.[55] Under Colón's aegis the pilots' licensing exams had become more rigorous; he had even ordered some previously licensed pilots to retake their exams.[56] Chaves, too, was a part of this new regime; one of his first actions after being appointed cosmographer in 1528 was to request permission to give daily lessons to the pilots on the use of charts and instruments.[57]

The composition of Chaves's proposed classes indicates the ways in which the theory-proponents wanted to reform navigation. The authorization letter from the court noted Chaves's desire to give a daily lecture in his house to pilots and seamen on "the use of the astrolabe and quadrant and sea chart, with the treatise of the *Sphere*." Although the ability to use a chart, an astrolabe and a quadrant was already supposed to be part of the licensing exam for pilots, the extent to which pilots found these skills useful at sea was still in dispute twenty years later, as was the extent to which the pilots were learning enough in the classes to use the instruments properly.[58] Since the main use of an astrolabe or quadrant at sea was to find latitude, this emphasis on instruments implied a reliance on latitude measurements, and so on astronomy.

Furthermore, Chaves did not plan to limit his classes to the use of instruments. He also proposed to teach the pilots from the standard introductory astronomy text, Sacrobosco's *Sphere*.[59] This would probably have involved discussions of the sphericity of the earth, the zodiac, the moon and tides, and the equator, tropics, and poles. This curriculum assumed that pilots needed to understand the reference system of elementary astronomy if they were to find latitude at sea. The available methods required them not only to observe the altitude of the sun or north star, but also to know which tables to use, and how to apply the necessary corrections. Most sixteenth-century navigation textbooks included discussions of these issues and offered detailed rules to follow, in addition to tables and explanatory diagrams.[60] In fact, the need for such tables and calculations was one of the reasons cited later for requiring pilots to be able to read and write, another project of the theory proponents.[61] The methods in the textbooks could all be learned by rote, but Chaves, with the strong support of Colón, wanted the pilots to understand the astronomy underlying them, on the conviction that this would help them navigate.

When Gutiérrez gained control of the education of the pilots in the early 1530s, he presided over a distinct decrease in the theoretical content of the classes. In discussing the classes, he made no mention of the *Sphere* or astronomy, but quickly passed on to his expertise in making nautical instruments. Other cosmographers later derided his lack of learning, complaining that a man who didn't know the *Sphere* or understand Latin could hardly be con-

sidered an expert.[62] A midcentury investigation into practices at the Casa de la Contratación branded his classes as superficial and corrupt. He was accused not only of accepting bribes to pass unfit candidates (a common complaint in the sixteenth century), but of providing a list of questions and answers for would-be pilots to memorize.[63] Pedro de Medina, Gutiérrez's chief competitor as a teacher during the 1540s, further testified that if the candidate could not read this list (and thus did not qualify as even marginally educated), Gutiérrez would teach it to him orally.[64] The thrust of the complaint was that the candidates could then recite the answers without actually understanding any of the cosmography underlying them. Certainly if Gutiérrez did not understand the astronomical underpinnings of celestial navigation, he could not be expected to teach it to the pilots.

Though the argument over the extent to which pilots needed to master astronomy seems far removed from the concerns involved in making a sea chart, in practice the two were closely linked. Pilots trained in astronomy and the use of instruments could use latitude measurements to navigate, and thus would be more aware of the exact location of lands and ships at sea. Pilots not so trained relied instead on the compass bearings between places, which left them, according to one of the theory proponents, "ignorant and deprived of the general and well-founded science and art [*ciencia y arte*] by which they needed to govern themselves."[65]

The ability to navigate by compass bearings was precisely what Gutiérrez's charts facilitated. According to the pilots, the reason Gutiérrez's charts were more useful than those matching the *padrón real* was because its double scale allowed them to use compass bearings to navigate instead of having to rely on latitude measurements. They considered the compass to be their primary tool; the pilots' guild later compared a ship without a compass to a man without eyes.[66] Though all of the pilots had to know how to take latitude measurements from the sun and North Star, they consistently complained that these were unreliable, since the weather might not permit observations for several weeks at a time, and when it did the results were often inaccurate.[67] Using the two-scale charts they could travel by compass bearing, perhaps using occasional latitude observations as a check, and without having to adjust for magnetic declination. For those sailing by compass, the pilots agreed, the charts were extremely useful.

The charts matching the *padrón real*, which the pilots called latitude charts (*cartas de altura*), could not be used in this way because in making sure that ports were put in the correct latitudes, the chart makers changed the bearings between them. In fact many of the pilots said they didn't know how the latitude charts could be used.[68] The theory proponents explained that the charts were intended to be used with frequent latitude observations, which then corrected courses set by a compass regularly adjusted for magnetic declina-

tion.[69] This method, however, was too complicated and cumbersome for most of the pilots. To them, the practical utility of the two-scale charts was both obvious and all-important. Indeed, it was at the request of the pilots that Cabot and Gutiérrez (or so they claimed) had begun to sell two-scale charts in the first place.[70]

In essence, then, everyone agreed that available charts limited the possible methods of navigation. The theory proponents wanted to use this fact to force the pilots to navigate by latitude, by controlling the charts they used. The pilots, with the help of Cabot and Gutiérrez, successfully resisted this move, instead retaining (for a time) the charts that allowed them to navigate by compass bearing. The incentive of a sufficiently large and unified market (the pilots), as well as an ideological commitment that harmonized with the pilots' demands, convinced Cabot and Gutiérrez to defy the rules by making and selling two-scale charts instead of ones matching the pattern chart. They even partially succeeded in convincing the officials in Seville to ignore the regulations they were sworn to uphold.[71] These officials listened to the warnings of the pilots and agreed that forcing them to use charts they did not understand could only cause shipwrecks and loss of life and property; they counseled that any changes be slow and cautious.[72] But the Council of the Indies, more isolated from the pilots by its position at court, found these arguments less compelling, and banned the two-scale charts.[73] By 1545, ten years after they had constructed the chart, and after twenty years of fighting for control of navigation, the theory proponents had won.

SEA CHARTS AS TERRITORIAL CLAIMS

So far this has been a local argument between two factions of cosmographers in Seville. The theory proponents, due to both their ideas of navigation (which privileged latitude over compass bearings) and their ideas of representation (which placed a high value on literal representation) favored the charts matching the *padrón real*, which indeed they had helped construct in the first place. They also placed great importance on the pilots' ability to report back about where they had been so the charts could be improved. This would necessitate their being literate (so they could keep good records) and making frequent latitude observations (so they had data to report). Cabot and Gutiérrez supported instead the arguments of the pilots, that any sea chart that allowed the pilot to guide a ship safely was a good chart. As a group of pilots explained, there were many types of charts for different purposes, but the pilots' own charts served as "nothing more than to go from here to the Indies." They suggested that for other concerns, such as territory and boundaries, the Casa officials instead use charts "of all the universe,"

which were clearly distinct from the sea charts used by the pilots.[74] The theory proponents, however, rejected this distinction, insisting that one type of chart be fit for all uses.

Once the debate left Seville, it ceased to center on the practical needs of the pilots, and focused instead on other uses of charts. The pilots demanded only that the charts be useful, that is, that they provide an algorithm for crossing the ocean. While the cosmographers did want charts that were useful at sea, they also asked that the charts be accurate reflections of the world. As such, the cosmographers' charts could be used to support Spanish territorial claims as well as to cross the Atlantic, while those the pilots preferred could not. While by no means central to the cosmographers' disagreements with the pilots, these diplomatic implications did give the cosmographers additional leverage with the Council of the Indies. Once sea charts began to take on a larger political significance, the choice of which chart to use became more than a technical issue, and became too important for pilots and cosmographers to settle among themselves.

In sixteenth-century Spain, the exact location of territories was a politically sensitive issue, as all the cosmographers were well aware. To understand this we have to go back to 1494, when the treaty of Tordesillas set the boundary between Spanish and Portuguese territories. Though the treaty specified a line of longitude 370 leagues west of the Cape Verde Islands, it did not specify which island in the group.[75] It also failed to indicate any landmark to locate the line, for the simple reason that no one knew what was there. These details were supposed to be worked out by a bilateral commission, but the commission never met. Despite some diplomatic skirmishes, both countries were too involved in other parts of the world to worry overmuch about the exact boundary line.[76] Though the line of demarcation was officially a line of longitude, and thus something to be determined by cosmographers, at first it was not very important in practice.

All this changed with Magellan. He left Portugal for Spain promising to prove that the Spice Islands fell into Spanish territory (fig. 3.3).[77] In 1522, the successful return of one of his three ships inflamed Spanish hopes of riches in the East, and caused both sides to reopen the question of demarcation. Both agreed that the obvious solution would be to extend the line of demarcation to complete the great circle, thus creating a line in the east. Locating this line, however, was problematic, even in theory. First the parties had to agree on the location of the line in the Atlantic, which involved agreeing on a starting place and on the size of the earth (and so the conversion between leagues and degrees). Then they had to draw a line exactly halfway around the world from the first, and (more important) agree where that line was in reference to known places, since neither side had any reliable longitude measurements.

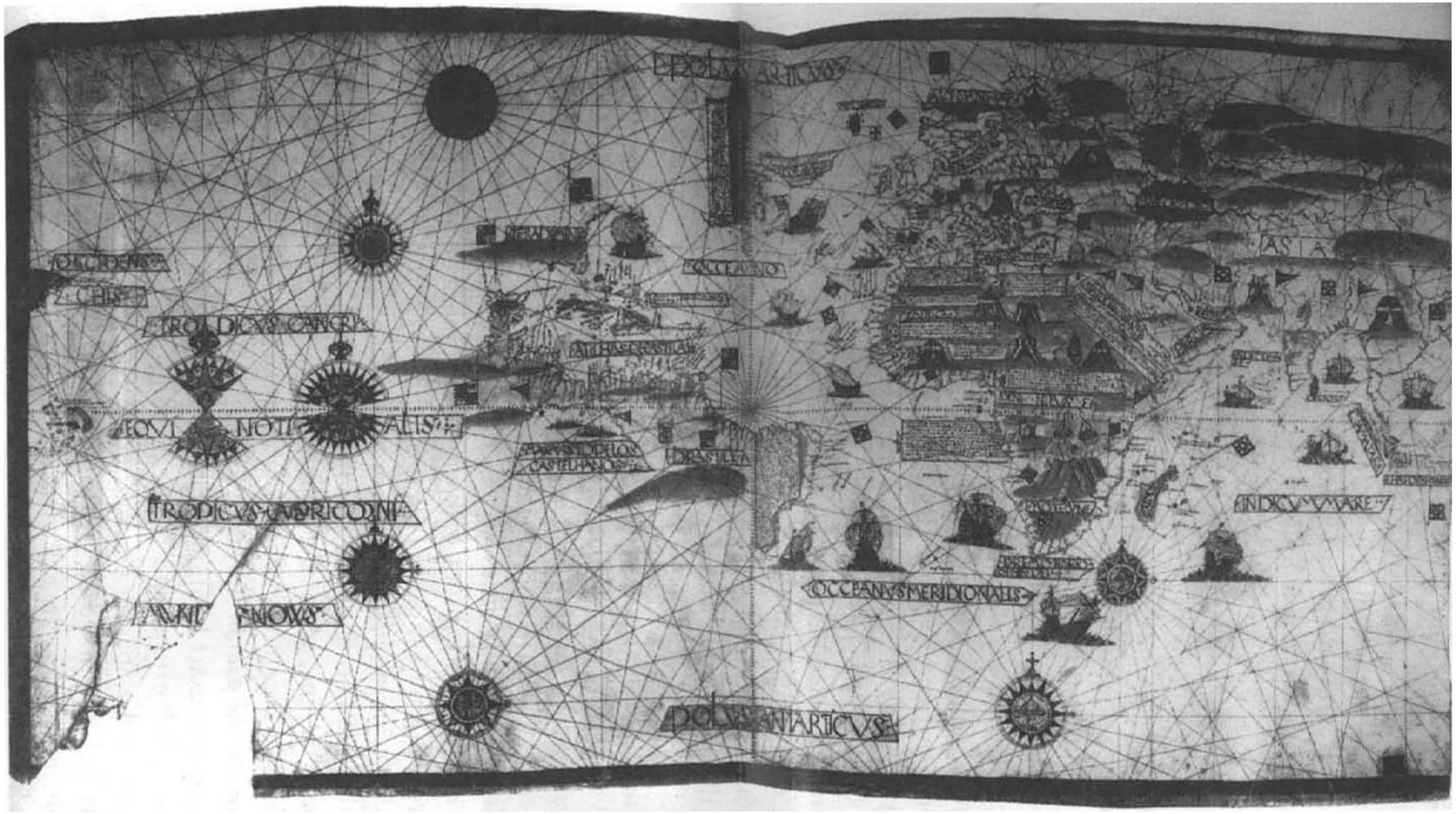

Figure 3.3 Anonymous chart circa 1518, known as Kunstmann IV, attributed to Pedro Reinel. Formerly at the Ameeribibliothek, Munich, present whereabouts unknown. This chart may have been one of those used to convince the Spanish king that the Spice Islands (far left) fell within his demarcation, as their placement on the chart implies.

In 1524 Spanish and Portuguese delegates met to try to decide the locations of the demarcation lines.[78] Hernando Colón served as one of the delegates for Spain. Sebastian Cabot was on hand as an advisor, along with a variety of other pilots and cosmographers. These talks hinged on cosmographical issues—the length of a degree, the locations of certain groups of islands, and the ability to measure longitude at sea. The talks were inconclusive, and the issue remained unsettled until 1529 when the Spanish sold all rights in the Spice Islands to Portugal.

The discussions did, however, serve to underscore both the unreliability of the pilots' reports (since none of them could agree on locations of the islands) and the utility of each side's charts as evidence of the locations of places. In fact, much of the diplomatic maneuvering centered on charts. The Portuguese withdrew from discussion several of the charts and globes they had prepared once it became apparent that they could be used to support Spanish claims. Whether this was a dispute over projections or pure obstructionism, the result of the political maneuvering was to paralyze the discussions.[79] The Spanish, for their part, advocated the use of older charts, since only recently had the Portuguese had any motive for falsifying the distances.[80]

Neither side seems to have expected the talks to be decisive. Perhaps this was due to the considerable technical difficulties in deciding the longitude of the islands, for the uncertainties were huge. The Spanish team pointed out that between their account of travel to the west, and the Portuguese account of travel to the east, they failed to account for almost 50 degrees of longitude, a substantial percentage of the earth. Hernando Colón considered the location of the line of demarcation too uncertain to provide convincing proof of Spanish ownership of the Moluccas. He advised that the Spanish instead assert ownership by right of discovery, and leave to the Portuguese the problem of proving any treaty rights.[81] Perhaps, also, the discussions were hindered by the improbability of either country being willing to give up valuable property to comply with a disputed expert ruling. Only a unanimous decision by all the cosmographers could be expected to exert the necessary moral force, and the technical difficulties were too great to expect such unanimity. It appears that the Portuguese believed the Moluccas were probably on the Spanish side of the line, and so determined to obstruct the talks.[82]

Thus when the committee of Spanish cosmographers gathered in Seville in 1535 to revise the *padrón real*, they were all keenly aware of the political implications of the exact locations of lands. Cabot had been present at the negotiations with Portugal, and one of the aims of his voyage in 1526 had been to reinforce the Spanish presence in the East Indies. Falero, who was born in Portugal, had first come to Spain with Magellan and helped him to convince the Spanish that the Spice Islands would fall within their demarcation. Though the other cosmographers had less direct ties with the territor-

ial dispute, they could not have been unaware of it. Furthermore, when the *padrón* was investigated in the 1540s, one of the issues discussed was whether either of the two competing charts placed territories claimed by Spain on the Portuguese side of the line.

The legal testimony directly reflected concerns about demarcation, especially in the questions asked of each witness. Sancho Gutiérrez made the diplomatic importance of the charts explicit. Discussing the charts made by his father, he argued that "although in the locations of the land the charts do not differ" one type was better to use than the other, because it minimized the risk of foreigners *misunderstanding* the charts, and so coming to the *false* opinion that certain areas were outside of Spanish territory.[83] A representation needed not only to be accurate, but also transparent to even a hostile observer. In rebuttal, Diego Gutiérrez asked the defense witnesses whether the chart misplaced the line of demarcation.[84] Falero, Mexía, and Chaves condemned the two-scale chart on the issue, warning that since the chart misplaced latitudes in the New World, it decreased distances, and so moved the line of demarcation in Portugal's favor.[85] This claim still involved an interpretation of the chart, but an interpretation that they judged valid. This was not an argument the Council of the Indies could ignore.

These cosmographers were not suggesting that anyone falsify charts to support Spanish territorial claims, although perhaps only because they did not think falsification necessary in this case. In their view, however, all charts made claims about the locations of overseas territories, regardless of their intended use. They rejected the pilots' claim, that different types of charts with different uses should be judged only according to that use, on both intellectual and practical grounds: intellectual, because they did not believe that a chart with an inaccurate picture of the world could possibly be useful, and practical, because they did not trust the potential users of charts to respect the intention of the makers. Only a faithful and accurate representation of the world could be useful simultaneously to navigators (provided they used the proper astronomical methods) and to diplomats. All charts should mirror the world.

CONCLUSIONS

The theory proponents and the pilots disagreed about the role that eyewitness experience should play in the construction and evaluation of sea charts, about whether a general knowledge of astronomy was more important to navigation than local knowledge of winds and currents, and about the link between charts as tools of navigation and charts as pictures of the world. Most of these issues, however, were ignored by the Council of the Indies.

The theory proponents were able to gain the support of the council in large part because of the growing political sensitivity of charts. Once the council approved the charts of the theory proponents, however, the rest of their reforms followed. Once the placement of lands on a sea chart was no longer simply a technical matter, but part of a larger constellation of diplomatic claims, the pilots ceased to be the ultimate arbiters of the quality of any given chart, and the ability to describe locations accurately became more central to navigation. Though it did not hurt that the theory proponents were more likely to have friends at court than were their opponents, this contact also made them more sensitive to political concerns. Their ability to speak to concerns about both demarcation and the accuracy of charts brought them the approval of the Council of the Indies, and so support in their attempts to reform navigation. Just a few years later the council chose Chaves to be pilot major and created a new position of professor of cosmography which went to his son. These changes consolidated the control of navigation by cosmographers.

Making sure that ships could safely cross the ocean was important to the Spanish state because they carried the trade that increasingly supported both the Spanish economy and the overseas colonies. The technical side of navigation, including the charts used, was usually relegated to a small team of experts. After Magellan's voyage increased Spanish interest in the East Indies, however, the political importance of the exact locations of territories focused increasing attention on representations of the world, including sea charts. This provided an opportunity for a small group of reformers to argue for the importance of astronomical methods of navigation, on the grounds that they allowed pilots to report accurately on the positions of the ports they visited. The spread of astronomical methods and the subsequent improvements in techniques of navigation thus owed far more to the territorial preoccupations of the Spanish crown than to any practical problems in guiding ships across the ocean. The politicization of cosmography was instrumental in changing the approach to navigation from pragmatic to theoretical, and so in spreading the idea that theoretical knowledge was indeed useful in practice.

Notes

This article forms a part of my dissertation, *Cosmographers vs. Pilots: Navigation, Cosmography, and the State in Early Modern Spain*. I am grateful for research support from the University of Wisconsin, the Fulbright organization, the National Science Foundation, and the Spencer Foundation.

1. Cosmography in Spain has been the subject of much recent research. See, for example, Mariano Esteban Piñeiro, "Los Oficios Matemáticos en la España del Siglo XVI," in *II trobades d'història de la ciència i de la tècnica*, ed. Vicente L. Salavert, Víctor Navarro Brotóns,

Mavi Corell (Barcelona: Institut d'Estudis Catalans, 1994), 239–251; Víctor Navarro Brotóns, "La Cosmografía en la Época de los Descubrimientos," in *Las relaciones entre Portugal y Castilla en la época de los descubrimientos y la expansión colonial*, ed. Ana María Carabias Torres, Acta Salmanticensia Estudios Históricos y Geográficos, 92 (Salamanca: Ediciones Universidad de Salamanca, 1994), 195–205; M. I. Vicente Maroto and M. Esteban Piñeiro, *Aspectos de la Ciencia Aplicada en la España del Siglo de Oro* (Madrid: Junta de Castilla y Leon, 1991). For a review of literature in the field, see Mariano Esteban Piñeiro, "Cosmografía y Matemáticas en la España de 1530 a 1630," *Hispania* 51, no. 177 (1991): 321–337.

2. Ricardo Cerezo Martínez, *La Cartografía Náutica Española en los Siglos XIV, XV, y XVI* (Madrid: Museo Naval, 1994), 141. In his appendix he lists all known sea charts from the period.

3. The majority of these texts are now in the Archivo General de Indias (AGI) in Seville, Spain, primarily in the legal records (section *Justicia*).

4. José Cervera Pery, *La Casa de Contratación y el Consejo de Indias (Las Razones de un Superministerio)* (Madrid: Ministerio de Defensa, Secretaría General Técnica, 1997), 13–18; Ernesto Schäfer, *El Consejo Real y Supremo de las Indias; Su Historia, Organización y Labor Administrativa Hasta la Terminación de la Casa de Austria* (Seville: Universidad de Sevilla, Publicaciones del Centro de Estudios de Historia de América, 1935), especially 82ff.

5. Art (*arte*) and science (*ciencia*) were generally treated as synonyms, contrasted with the office (*oficio*) of a pilot, which involved the traditional methods learned at sea. The cosmographers did not wholly discount these traditional methods, but wanted the pilots to learn astronomical methods in addition. For a discussion of this distinction, see Maria Isabel Vicente Maroto, "El Arte de Navegar," in *Felipe II, la Ciencia y la Técnica,* ed. Enrique Martínez Ruiz (Madrid: Actas Editorial, 1999), 343–344. On navigation as part of cosmography, see AGI, Justicia, 1146, N. 3, R. 2, block 3, image 102, 3 September 1544 statement from Pedro de Medina; on the necessity of astronomical observations and general rules, see images 336 and 339–340, 10 April 1545 statement from Alonso de Chaves.

6. On the chart's construction, see Cerezo Martínez, *Cartografía Náutica Española*, 201–204. Most information on the chart comes from a 1544–1545 dispute (AGI, Justicia, 1146, N. 3, R. 2), which prompted discussion of its construction, and from Alonso de Santa Cruz's 6 September 1549 letter to Hernán Pérez de la Fuente (AGI, Justicia, 945, ff. 168r–171r).

7. On the idea of a *padrón*, see Cerezo Martínez, *Cartografía Náutica Española*, 137–140. On inspections intended to ensure the conformity of the charts, see AGI, Indiferente, 1207, N. 61 (1546 discussion of procedures) and AGI, Indiferente, 2005 (1565 order on the disposition of instruments failing inspection).

8. Cerezo Martínez, *Cartografía Náutica Española*, 190. The relevant orders are dated 6 October 1526 and 16 March 1527, AGI, Indiferente, 421, L. 11 f. 234rv and L. 12, f. 40rv.

9. For a biography of Colón, see Tomás Marín Martínez, "Estudio Introductorio," in *Catálogo Concordado de la Biblioteca de Hernando Colón*, ed. Tomás Marín Martínez, José Manuel Ruiz Asencio and Klaus Wagner (Cabildo de la Catedral de Sevilla, Fundación MAPFRE-América, and Editorial MAPFRE, 1993), 27–351.

10. AGI, Indiferente 421, L. 13, f. 82r, 4 April 1528 letters to Chaves and officials of the Casa de la Contratacíon.

11. His work as a cosmographer is inferred from his possessions listed at the time of his marriage that year. Paulino Castañeda Delgado, Mariano Cuesta Domingo, and Pilar Hernández Aparicio, *Transcripción, Estudio y Notas del Espejo de Navegantes de Alonso de Chaves* (Madrid: Instituto de Historia y Cultura Naval, 1983), 15; José Pulido Rubio, *El Piloto Mayor: Pilotos Mayores, Catedraticos de Cosmografía y Cosmógrafos de la Casa de la Contratación de Sevilla* (Seville: Escuela de Estudios Hispano-Americanos, 1950), 609.

12. AGI, Indiferente, 421, L. 12, f. 40rv, 16 March 1527.

13. On the book, see AGI, Justicia, 1146, N. 3, R. 2, image 97, Pedro de Medina, 3 September 1544. Ricardo Cerezo Martínez argued (*Cartografía Náutica Española*, 191–192, 201–203) that a chart was indeed finished at this time, but that later administrators were unaware of it.

14. AGI, Indiferente, 1961, L. 3, f. 276rv, 20 May 1535.

15. AGI, Justicia, 836, N. 6, images 580–625, testimony from various pilots. On Gutiérrez, see Robert W. Karrow, Jr., *Mapmakers of the Sixteenth Century and Their Maps: Bio-Bibliographies of the Cartographers of Abraham Ortelius, 1570* (Chicago: Speculum Orbis Press, 1993), 285–287. See also the discussions in Ursula Lamb, "Science by Litigation: A Cosmographic Feud," *Terrae Incognitae* 1 (1969): 40–57, and Ursula Lamb, "The Sevillian Lodestone: Science and Circumstance," *Terrae Incognitae* 19 (1987): 29–39.

16. On Cabot's appointment as pilot major, see José Toribio Medina, *El Veneciano Sebastián Caboto al Servicio de España, y Especialmente de su Proyectado Viaje á las Molucas por el Estrecho de Magallanes y al Reconocimiento de la Costa del Continente Hasta la Gobernación de Pedrarias Dávilla*, 2 vols. (Santiago de Chile: Imprenta y Encuadernación Universitaria, 1908), vol. 1, 25–33. While this book remains the best source for Cabot's time in Spain, and especially for his voyage, the details of Cabot's early life are contentious. For a brief overview of the historiography, see Karrow, *Mapmakers*, 103–112.

17. Medina, *El Veneciano*, 1: 1–6. The actual extent of Cabot's experience is debated, but there is no doubt that he convinced the Spanish officials interviewing him.

18. Ibid., 303–313, 332. Vol. 2 contains many of the relevant documents.

19. AGI, Indiferente, 2005, undated petition from Cabot, reproduced in Medina, *El Veneciano*, 1: 507.

20. AGI, Indiferente, 1204, N. 21, undated petition from Gutiérrez, supported by pilots' petition with twenty-nine signatures from September 1533.

21. AGI, Contratación, 5784, L. 1, f. 58v, 21 May 1534 cedula giving Gutiérrez a salary of 6,000 maravedís (16 ducados) per year, though most cosmographers were paid 30,000 mrs or more. On prices, see AGI, Justicia, 836, N. 6; in 1551 Gutiérrez charged 4 ducados for a sea chart and 2 to 6 for lessons. On Sancho's inheritance, see Lamb, "The Sevillian Lodestone," 204–206.

22. Ricardo Arroyo Ruiz-Zorrilla, "Estudio," in *Tratado del Esphera y del Arte del Marear con el Regimiento de las Alturas*, by Francisco Falero (Madrid: Ministerio de Defensa; Ministerio de Agricultura Pesca y Alimentación, 1989), 9–10.

23. Francisco Falero, *Tratado del Esphera y del Arte del Marear con el Regimiento de las Alturas, con Algunas Reglas Nuevamente Escritas Muy Necessarias,* 1535, facsimile edition with introductory study and transcription by Ricardo Arroyo Ruiz-Zorrilla (Madrid: Ministerio de Defensa; Ministerio de Agricultura Pesca y Alimentación, 1989).

24. Mariano Cuesta Domingo, *Alonso de Santa Cruz y Su Obra Cosmografica,* 2 vols. (Madrid: CSIC, 1983), 1: 35–61.

25. Antonio Castro Díaz, *Los «Coloquios» de Pedro Mexía: Un Género, una Obra y un Humanista Sevillano del Siglo XVI* (Seville: Excma. Diputación Provincial de Sevilla, 1977), 75–84.

26. Arroyo Ruiz-Zorrilla, "Estudio"; Cuesta Domingo, *Alonso de Santa Cruz*, 1: 81; Castro Díaz, *Los «Coloquios» de Pedro Mexía*, 81–82.

27. AGI, Justicia, 1146, N. 3, R. 2, block 3, image 84, Gutiérrez's account of Suárez de Carbajal's statement.

28. Ursula Lamb ("Science by Litigation," 56) has argued that Suárez de Carbajal was trying to determine scientific truth by majority rule. I would argue instead that he was trying to find a way to reach a decision in the absence of conclusive data.

29. AGI, Justicia, 945, f. 168v, 6 September 1549 letter from Santa Cruz to Hernán Pérez de la Fuente.

30. This involved giving him an appointment as cosmographer. On gathering information, see AGI, Indiferente, 1962, L. 5, ff. 41v–42v, 20 and 21 November 1536. On his authority over Cabot, see AGI, Indiferente, 1962, L. 5, f. 41v, 20 Noember. 1536.

31. For their running battle over authority, see the petitions in AGI, Indiferente, 2005. For Santa Cruz's movements, see Alonso de Santa Cruz, *Crónica de los Reyes Católicos*, edition and study by Juan de Mata Carriazo (Seville: Publicaciones de la Escuela de Estudios Hispano Americanos de Sevilla, 1951), v.

32. For Santa Cruz's own account of his activities at the time, see AGI, Justicia, 945, f. 168v, 6 September 1549 letter to Hernán Pérez. For Pérez's interpretation, see his letter of 22 September 1549, AGI, Indiferente, 1093, N. 98. On 20 November 1549 Santa Cruz was charged with not attending licensing exams; see AGI, Justicia, 945, ff. 209v–211r.

33. AGI, Indiferente, 2005, various 1538 petitions.

34. AGI, Justicia, 1146, N. 3, R. 2, block 3, image 93, Pedro Mexía, 2 September 1544; block 3, image 97, Pedro de Medina, 3 September 1544; block 2, images 37–38, Alonso de Chaves, 9 September 1544.

35. "Coloquio Sobre las Dos Graduaciones Diferentes Que las Cartas de Indias Tienen," in *Disquisiciones Nauticas*, ed. Cesáreo Fernández Duro, Vol. 6: *Arca de Noé* (Madrid: Ministerio de Defensa, 1996 [1881]), 513. Though Fernández Duro identified the anonymous author as Hernando Colón, Ursula Lamb ("Science by Litigation," 50) has convincingly argued that the *coloquio* was instead written by Pedro de Medina.

36. AGI, Justicia, 1146, N. 3, R. 2, block 1, images 15–17, 5 May 1545 statement by Francisco Falero.

37. AGI, Justicia, 945, ff. 168v and 169rv, 6 September 1549 Santa Cruz to Hernán Pérez.

38. AGI, Justicia, 1146, N. 3, R. 2, block 3, image 94, Pedro Mexía, 2 September 1544, and image 339, Alonso de Chaves, 10 April 1545.

39. AGI, Justicia, 1146, N. 3, R. 2, block 3, image 99, Pedro de Medina, 3 September 1544.

40. AGI, Justicia, 1146, N. 3, R. 2, block 3, images 107–108 (both quotes), Diego Gutiérrez, 9 September 1544.

41. On Cabot and Gutiérrez, see AGI, Justicia, 1146, N. 3, R. 2, block 2, f. 14v and block 3, ff. 12r–13r. For denials, see AGI, Justicia, 1146, N. 3, R. 2, block 2, images 43 (Chaves) and 378 (Mexía). Falero (image 309) testified that there was a lot of controversy but everyone signed.

42. AGI, Justicia, 1146, N. 3, R. 2, block 3, image 371, undated 1545 statement.

43. In this it differs from the English context as described in Steven Shapin, *A Social History of Truth: Civility and Science in Seventeenth-Century England* (Chicago: University of Chicago Press, 1994). For a discussion of the basis for credibility critiquing Shapin, see Barbara J. Shapiro, *A Culture of Fact: England, 1550–1720* (Ithaca, N.Y.: Cornell University Press, 2000), especially 12–26, 70–76, and 120–127. Since the role of juries is central to her analysis of England, her findings are not directly applicable to Spain, but many similar factors apply.

44. For a biographical sketch of Medina see Pedro de Medina, *A Navigator's Universe: The Libro de Cosmographía of 1538 by Pedro de Medina*, ed. Ursula Lamb (Chicago: University of Chicago Press for the Newberry Library, 1972), 9–18.

45. See AGI, Indiferente, 1962, L. 6, f. 156r, granting the right to make and sell instruments; f. 164; ordering that he be given access to the *padrón*; AGI, Indiferente, 1963, L. 7, f. 19; ordering that the other cosmographers inspect Medina's charts and instruments; and f. 84v, ordering that there be no monopoly on making charts.

46. For speculation about Medina's intended role, see AGI, Indiferente, 2673, undated 1551 letter by Alonso Zapata, pilot, decrying rampant corruption among cosmographers in Seville. On the Gutiérrez family, see Chaves's later complaint in AGI, Justicia, 1146, N. 3, R. 2, block 2, f. 10r.

47. The ensuing litigation has been much discussed from a variety of points of view, most recently in Pablo Emilio Pérez-Mallaína Bueno, *Spain's Men of the Sea: Daily Life on the Indies Fleets in the Sixteenth Century*, trans. by Carla Rahn Phillips (Baltimore: Johns Hopkins University Press, 1998), 233–237. The fullest treatment is Lamb, "Science by Litigation." Many of the relevant documents are reproduced in José Pulido Rubio, *El Piloto Mayor de la Casa de la Contratación de Sevilla: Pilotos Mayores del Siglo XVI (Datos Biográficos)* (Seville: Tip. Zarzuela, Teniente Borges 7, 1923), 77–119, and Pulido, *El Piloto Mayor (1950)*, 482–534. The bulk of the original documents are found in AGI, Justicia, 1146, N. 3, R. 2.

48. Many charts of the period tried to deal with this problem by introducing multiple latitude scales; see D. Gernez, "Les Cartes avec Échelle de Latitudes Auxiliaire Pour la Région de Terre-Neuve," *Mededelingen: Academie Van Marine Van Belgie*, book 6 (1952), 93–117. On Gutierrez's charts in particular, see Cerezo Martínez, *Cartografía Náutica Española*, 205–208.

49. 10 April 1545 statement by Alonso de Chaves, AGI, Justicia, 1146, N. 3, R. 2, block 3, image 335; see also similar statements by Pedro Mexía (image 343, undated 1545) and Pedro de Medina (images 100–101, 3 September 1544).

50. Chaves, *Espejo de Navegantes*, 110.

51. AGI, Justicia, 1146, N. 3, R. 2, block 3, image 339, Alonso de Chaves, 10 April 1545.

52. AGI, Justicia, 1146, N. 3, R. 2, block 3, images 100–101, Pedro de Medina, 3 September 1544.

53. AGI, Justicia, 1146, N. 3, R. 2, block 3, image 224 (Francisco del Barrio); 149 (Alonso Martin), 165 (Cristobal Cerezo de Padilla), 170 (Alonso Perez), 181 (Francisco Guzado), and many others.

54. AGI, Justicia, 1146, N. 3, R. 2, block 1, image 8, 24 April 1545 petition from Pedro de Medina; block 3, image 338, Alonso de Chaves, 10 April 1545.

55. AGI, Patronato, 251, R. 22, 2 August 1527 cedula appointing Colón as acting pilot major, to be assisted by Alonso de Chaves and Diego Ribero.

56. See AGI, Indiferente, 2005, 1534 investigation of licensing exams, especially the testimony of Francisco Vanegas and Diego Ramirez, transcribed in Medina, *El Veneciano* 1: 507–512.

57. AGI, Indiferente, 421, L. 13, f. 295v, 21 August 1528 cedula authorizing the classes.

58. For the rules on licensing exams, see AGI, Patronato, 251 R. 22; the entire cedula has been reproduced in Pulido, *El Piloto Mayor (1950)*, 140–143. For pilots' testimony in 1544 about problems measuring latitude at sea, see below, note 67. On licensing pilots who could not use instruments at sea, see AGI, Justicia, 945, ff. 110v–112r (Pedro de Medina, 17 July 1549).

59. On the *Sphere* itself, see *The Sphere of Sacrobosco and Its Commentators*, ed. Lynn Thorndike (Chicago: University of Chicago Press, 1949); on its role in navigation texts of this period, see Pablo Emilio Pérez-Mallaína Bueno, "Los Libros de Náutica Españoles del Siglo XVI y su Influencia en el Descubrimiento y Conquista de los Océanos," in *Ciencia, vida y espacio en Iberoamérica* (Madrid: CSIC, 1989), esp. 477–478.

60. See, Martín Fernández de Enciso, *Suma de Geographia*, 1519, ed. M. Cuesta Domingo (Madrid: Museo Naval, 1987), 113–118 (tables ff. 87–110); Falero, *Tratado del Esphera* part 2, chs. 5–6; Chaves, *Espejo de Navegantes*, 149–160 (book 2, treatise 1, chapters 1–3).

61. AGI, Justicia, 768, N. 2; AGI, Indiferente, 1967, L. 16, ff. 312r–313r.

62. AGI, Justicia, 1146, N. 3, R. 2, block 2, image 38 (Alonso de Chaves, 9 September 1544); block 2, image 380 (Pedro Mexía, undated January 1545); block 3, f. 20r (Pedro de Medina, 3 September 1544).

63. AGI, Justicia, 945, section 4, f. 70rv (Hernando Blas, 27 May 1549); ff. 103r–104r (Sancho Gutiérrez, 11 July 1549); f. 112r (Pedro de Medina, 17 July 1549). This was part of an inspection of the Casa de la Contratación by the Council of the Indies. Gutiérrez died while appealing the sentence.

64. AGI, Justicia, 945, section 4, f. 112r, 17 July 1549 testimony.

65. AGI, Justicia, 1146, N. 3, R. 2, block 3, image 336, Alonso de Chaves, 10 April 1545.

66. AGI, Justicia, 1146, N. 3, R. 2, block 3, image 371, undated statement signed by about fifty-five pilots; AGI, Justicia, 792, N. 4, especially image 74, 1565 petition from the pilots guild to have a certain lodestone made available for remagnetizing their compasses.

67. AGI, Justicia, 1146, N. 3, R. 2, block 3, image 186 (testimony from Martin Lopez), image 203 (Pedro Camino), image 212 (Martin Sanchez), image 218 (Diego Sanchez Colchero), image 223 (Francisco del Barrio), image 234 (Tome de la Isla), image 250 (Hernando Blas), image 371 (statement from fifty-five pilots). All the witnesses cited here were pilots.

68. For being unable to use single-scale charts see the statements in AGI, Justicia, 1146, N. 3, R. 2, block 3, image 244 (Jeronimo Rodriguez), images 355–356 (six experienced pilots), image 371 (about fifty-five pilots). For one pilot who could use both types of chart, see image 347 (Hernan Rodriguez).

69. See for example AGI, Justicia, 1146, N. 3, R. 2, block 3, images 339–340, description by Alonso de Chaves.

70. AGI, Justicia, 1146, N. 3, R. 2, block 2, image 33 (Diego Gutiérrez, 28 August 1544); block 3, image 119 (Sebastian Cabot, 9 September 1544).

71. This charge was brought by Medina, and substantiated by the long-standing use of the two-scale charts even after they were banned; AGI, Justicia, 945, ff. 109v–110v, 17 July 1549 testimony.

72. AGI, Indiferente, 1093, N. 68, 5 April 1545 letter from the officials of the Casa de la Contratacíon to the prince.

73. AGI, Indiferente, 1963, L. 9, ff. 174v–176v, 22 February 1545 letter to the officials of the Casa de la Contratación.

74. AGI, Justicia, 1146, N. 3, R. 2, block 3, images 356–357, undated ca. 1544 petition from six pilots.

75. Antonio Rumeu de Armas, *El Tratado de Tordesillas*, Colecciones MAPFRE 1492 Colección América 92, 12 (Madrid: Editorial MAPFRE, 1992), 141–150, 169–175.

76. The most notable skirmish during this period was probably the arrest of eleven Portuguese sailors accused of being on the wrong side of the line of demarcation, which sparked official inquiries into the location of the line. Rolando A. Laguarda Trías, *El Predescubrimiento del Río de la Plata por la Expedición Portuguesa de 1511-1512* (Lisbon: Junta de Investigações do Ultramar, 1973), 91–113, esp. 96–97.

77. On Magellan, see Tim Joyner, *Magellan* (Camden, Maine: International Marine, 1992). On the cartographic importance of the debate over the Spice Islands, see Jerry Brotton, *Trading Territories: Mapping the Early Modern World* (Ithaca, N.Y.: Cornell Univ. Press, 1998), 119–150.

78. For a brief description of the meetings, see Rumeu de Armas, *El Tratado de Tordesillas*, 222–224. He blamed the lack of results on the obstructionism of the Portuguese representatives. Most of the expert opinions can be found in AGI, Patronato, 48, Ramos 12–17, and have been published in Martín Fernández de Navarrete, *Colección de los Viages y Descubrimientos que Hicieron por Mar los Españoles Desde Fines del Siglo XV, Vol. IV: Expediciones al Maluco = Viage de Magallanes y de Elcano* (Buenos Aires: Editorial Guarania, 1945), 296–335.

79. Ursula Lamb, "The Spanish Cosmographic Juntas of the 16th Century," *Terrae Incognitae* 6 (1974): 51–64, 55; Rumeu de Armas, *El Tratado de Tordesillas*, 223. Rumeu de Armas characterized the Portuguese as obstructive throughout, while Lamb argued that the political maneuvering hindered the experts' attempts to discuss freely all available data and suggested that the differences over the charts involved a disagreement over projection.

80. AGI, Patronato, 48, R. 13, image 5, undated 1524 opinion signed by Hernando Colón, Fray Tomás Durán, Doctor Salaya, Pero Ruiz de Villegas, Maestro Salazar, and Juan Sebastián del Cano.

81. AGI, Patronato, 48, R. 17, image 1, 17 April 1524 opinion of Hernando Colón.

82. Luis de Albuquerque, "O Tratado de Tordesilhas e as Dificultades Tecnicas da Sua Aplicação Rigorosa," in *El Tratado de Tordesillas y Su Proyeccion* (Valladolid: Seminario de Historia de America, Universidad de Valladolid, 1973), 131–132.

83. AGI, Justicia, 1146, N. 3, R. 2, block 3, image 359, undated spring 1545 statement from Sancho Gutiérrez. Emphasis mine.

84. Unsurprisingly, they all said no. AGI, Justicia, 1146, N. 3, R. 2, block 3, images 149ff. (question 13 and answers by pilots).

85. AGI, Justicia, 1146, N. 3, R. 2, block 1, images 13–14 (5 May 1545 statement from Francisco Falero); block 3, image 344 (undated 1545 statement from Pedro Mexía); block 3, images 336–338 (10 April 1545 statement from Alonso de Chaves); Chaves did not mention the demarcation directly, but focused on the errors in distances and positions caused by the double scale.

From Blowfish to Flower Still Life Paintings

Classification and Its Images, circa 1600

CLAUDIA SWAN

At its broadest span, this essay is about how early modern (pre-Linnaean) natural history organized its experience of the natural world. More narrowly, I am conerned with the *visual* organization of the natural world by means of naturalistic figuration (mimetic pictures) and schematic representation (grids). Much of the chapter will focus on naturalistic representation in the classification of blowfish in the first decade of the seventeenth century in the Netherlands, and on grids and schematic tables in natural history of the period. I conclude by suggesting that the coexistence of these two modes of representation is a crucial feature of early modern natural history and that, taken together, they may help to explain how botanical still-life paintings are structured, compositionally and epistemologically speaking. In other words, this essay treats the organization of the natural world by images and the impact of natural history's modes of visualization on the new genre of flower pictures ca. 1600.

CHAOS IN THE MICROCOSM: THE CASE OF ULISSE ALDROVANDI

Ulisse Aldrovandi, who died in 1605 at the age of 83, ranks among the most renowned sixteenth-century natural historians. Aldrovandi was professor of logic and philosophy and lecturer in simples (medical preparations from plants and minerals) at the University of Bologna. From 1568 until his death he served as director of the university's botanical garden, which he helped found. During his lifetime, Aldrovandi was known to European medics, naturalists, princes, clerics, pharmacists, and scholars as a collector who amassed a truly staggering number of natural specimens, which he housed in a kind of proto-museum, and many of which were illustrated in his massive volumes on insects, birds, wood, metals, monsters, and other classes of *naturalia*.[1] His

fame endured: in 1750 the great naturalist Georges-Louis Leclerc, Comte de Buffon (1707–88), dubbed him "the most diligent and knowledgeable of naturalists" and philosopher/encylopedist Denis Diderot (1713–84) referred to him as "the most universal and complete modern naturalist."[2]

Diligent, knowledgeable, universal, and complete: these adjectives were used even in the sixteenth century to describe Aldrovandi's efforts to observe the natural world and to make it available for observation. Buffon and Diderot, taken together, offer an apt, if antithetic, introduction to Aldrovandi's natural history. Unlike his exact contemporary Carl von Linné/Carolus Linnaeus (1707–78), Buffon did not believe in the necessity of systematic taxonomy. Diderot in his turn drove the production of that immense and powerful machine of calibrated knowledge, the *Encyclopédie*. While Aldrovandi amassed, arranged, studied, taught, and published as many specimens of the natural world as he could get his hands on, he did not find it necessary to offer a systematic mode of organization for them. In the sixteenth century, naturalists resorted regularly and without apology to what subsequent natural historians would take to be arbitrary and convenient modes of organization.[3] The alphabet, for example, was sufficient for Leonhart Fuchs, one of the three so-called fathers of German botany and the author of a suite of volumes on the plant world first published in the 1540s. Generally speaking, very broad morphological or Aristotelian classes served as the brackets between which sixteenth- and seventeenth-century naturalists arranged the stuff of nature, which they so eagerly tracked down, studied, observed, dissected, dried, bought, sold, taught, published, displayed, advertised.[4]

In 1595, Aldrovandi described his collection as follows:

> Today in my microcosm, you can see more than 18,000 different things, among which 7000 in fifteen volumes, dried and pasted, 3000 of which I had painted as if alive ("*al vivo*"). The rest—animals terrestrial, aerial and aquatic, and other subterranean things such as earths, petrified sap, stones, marbles, rocks, and metals—amount to as many pieces again. I have had paintings made of a further 5000 natural objects—such as plants, various sorts of animals, and stones—some of which have been made into woodcuts. These can be seen in fourteen cupboards, which I call the Pinacotheca. I also have sixty-six armoires, divided into 4500 pigeonholes, where there are 7000 things from beneath the earth, together with various fruits, gums, and other very beautiful things from the Indies, *marked with their names, so that they can be found* (emphasis added).[5]

Contemporary observers were regularly stupefied by the contents of Aldrovandi's collection—his microcosm, as he calls it here. One visitor wrote of his heart being aflutter and his breath bated in anticipation of seeing all

that Aldrovandi had amassed.[6] In the final years of his life, Aldrovandi arranged to have ownership of what he even called the "eighth wonder of the world" transferred to the city of Bologna, a gift accepted gladly by the city's senators.[7] Aldrovandi's efforts are exemplary of what Paula Findlen has called Renaissance curiosity (as opposed to Baroque wonder), of the efforts to contain the infinite manifestations of nature in a single space—also called a museum.[8] Curiosity, however, did not always sponsor recognizable modes of classification.

One organizing principle for Aldrovandi's efforts, as for his possessions, is to be found in the praxis of medicine. Some of the most noteworthy contents of his museum and others of the time had or were thought to have medicinal application—from bezoar stones to dragon skeletons to myriad plants and spices. But if his own notes are any indication, to enter the space of Aldrovandi's microcosm was to give way to what seems from the present perspective of the life sciences relative chaos—chaos in pigeonholes and armoires. Likewise, the headings under which he collated his working notes were distinctly rudimentary from the point of view, say, of systematic taxonomy. They were arranged alphabetically, topically, and geographically. The staggering number of images of the contents of the collection he had made and that he stored in the collection itself is important too. Not because these images contributed to the classification of the contents, but because the net effect of their presence would have been to mirror, and to multiply, the vast number of items at hand. It comes as something of a relief when Aldrovandi tells us that the forty-five hundred pigeonholes in the sixty-six armoires in which he had placed seven thousand dried specimens were "marked with their names, so that they can be found."

THE ENDS OF NATURALISM: BLOWFISH

In the brief description of his collection cited above, Aldrovandi enumerates the specimens he owns in the same breath as images of such objects, which in their turn constitute a substantial portion of the whole. The images Aldrovandi cites are continuous with the rest of the collection in a significant regard: they are, as we know from the woodcuts made for publication in the volumes he authored, naturalistic representations of natural specimens. They were, as he specifies here and elsewhere, drawn or painted *al vivo*.[9] What role do such images—purposefully morphological characterizations—play in contemporary classificatory schemes and efforts?

The blowfish and, specifically, the blowfish as it came to be represented in the context of Dutch natural history ca. 1600 may offer an answer to this question. The blowfish was a widely popular specimen in natural history ca.

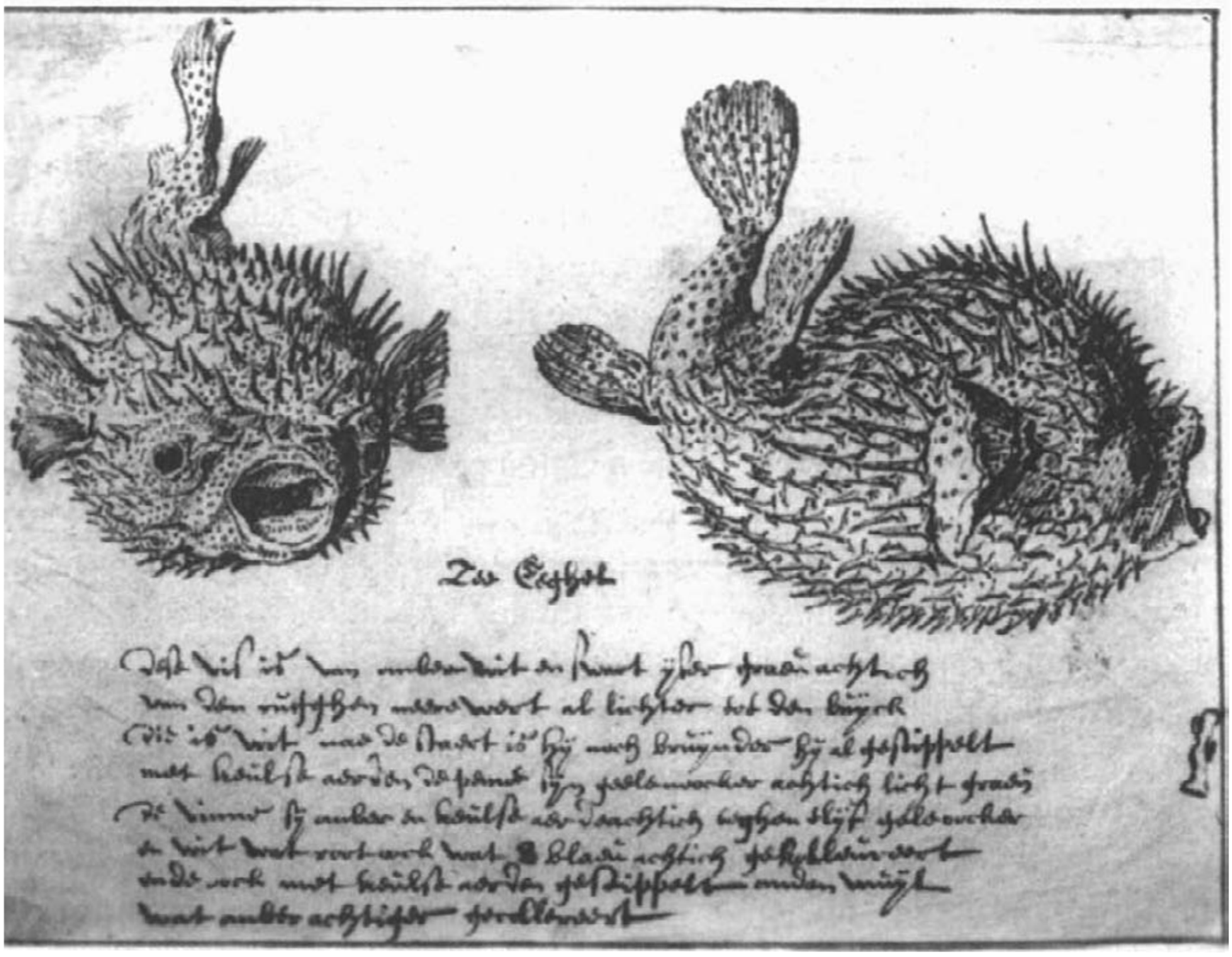

Figure 4.1 Jacques de Gheyn II, *Blowfish*, pen and ink drawing, ca. 1605 (Rijksmuseum, Amsterdam). Photo courtesy of the Rijksmuseum–Stichting, Amsterdam.

1600, prized for its exoticism.[10] On the evidence of contemporary prints we know blowfish to have been displayed prominently in a number of illustrious collections, where they frequently were hung from ceilings.[11] A single specimen was also depicted by the Dutch artist Jacques de Gheyn II (1565–1629). De Gheyn cultivated close contacts with members of the medical faculty at Leiden University during the years that he lived in the city of Leiden and his drawing of a blowfish is coeval with published accounts by the great botanist and fellow Leidenaar Carolus Clusius (1526–1609) of what Clusius declared to be four different kinds of blowfish. Close analysis of de Gheyn's and Clusius's verbal and pictorial descriptions of the blowfish is especially revealing—of the difference between an artistic representation of a natural historical specimen and a natural historical representation of the same, as well as of the ways in which naturalistic representation served the ends of contemporary classification strategies.

De Gheyn's drawing of a blowfish (*Diodon hystrix;* fig. 4.1), preserved in its inflated form, is dated on stylistic grounds to the first decade of the seventeenth century. It consists of two views of the dead fish, frontal and lateral, and a lengthy inscription. In translation, the inscription reads:

> Sea-Hedgehog—this fish is umber white and iron black grayish/ becoming lighter from the back down to the belly/ this is white toward the tail it is even browner and spotted/ with Cologne earth the spines are yellow ochreish light gray/ the fins are umber and Cologne earthish against the body yellow ochre/ and white somewhat red and also somewhat blueish in color/ and also spotted with Cologne earth and the jaw/ rather umber-like in color.[12]

De Gheyn may have observed this fish in a private collection, or among the natural historical specimens belonging to Leiden University. In 1601, he was commissioned by Dr. Pieter Pauw, professor of anatomy and botany, to engrave a plan of the botanical garden (fig. 4.2).[13] De Gheyn's is a schematic plan, intended to describe the layout of the garden. It contains individual plots in which botanical specimens were planted and from which their identification and uses were taught to students of *materia medica*—the makings of medicines. This practice is illustrated by the figure of the robed professor,

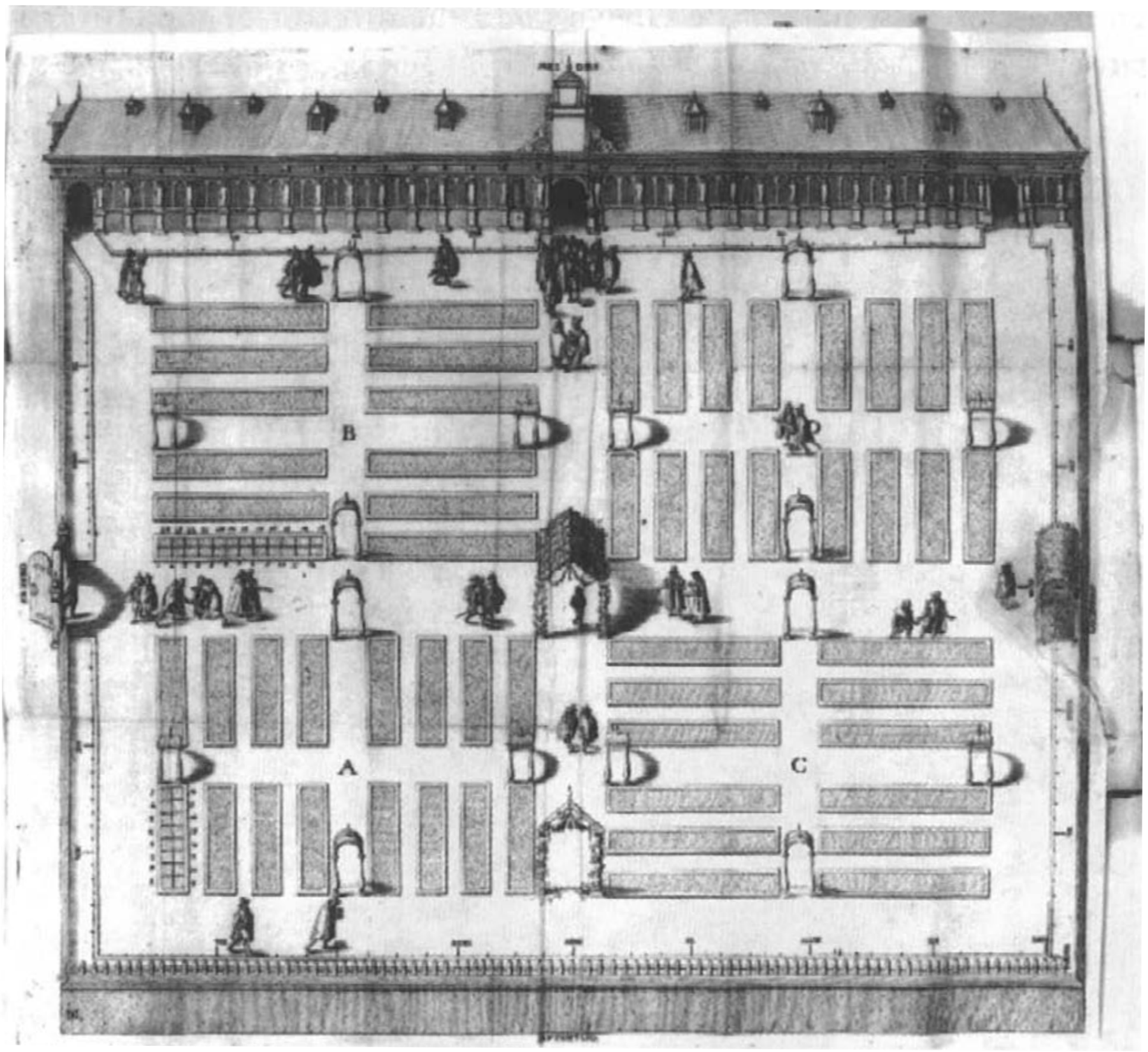

Figure 4.2 Jacques de Gheyn II, *Leiden University Hortus Publicus*, engraving, 1601. Photo courtesy of National Herbarium of the Netherlands, Leiden.

surrounded by an attentive audience, in the distant center of the image; he points to one of the plots in the garden, in much the same way as we know the medical faculty to have taught from the contents of the garden in the years around 1600.[14] In effect, de Gheyn's plan of the garden records its physical characteristics as well as its function within the university curriculum; like the anatomical theater, constructed in the mid-1590s, the university's collection of *naturalia* served as a focal point in medical instruction.

In the gallery at the far, western edge of the garden, which was constructed in 1599, specimens of a variety of *naturalia* were housed. A carcass of a blowfish is listed in the two existing inventories of the gallery, alongside a number of rarities including coral, an imbricated shell, the beak of a foreign bird, an Indian ink pot, a crab, pygmy clothing, two Indian hammocks, walrus teeth, and the like.[15] That the blowfish was a prized item in the collections of the Leiden University is also shown by its inclusion in another plan of the garden, by William Swanenburgh and dated 1610 (fig. 4.3), by which time the garden and the anatomical theater had become tourist attractions.[16] The blowfish was also recorded in a major natural history text written by a close associate of de Gheyn's and the director of the university garden—Clusius's *Exoticorum Libri Decem* (Ten books of exotica), a vast

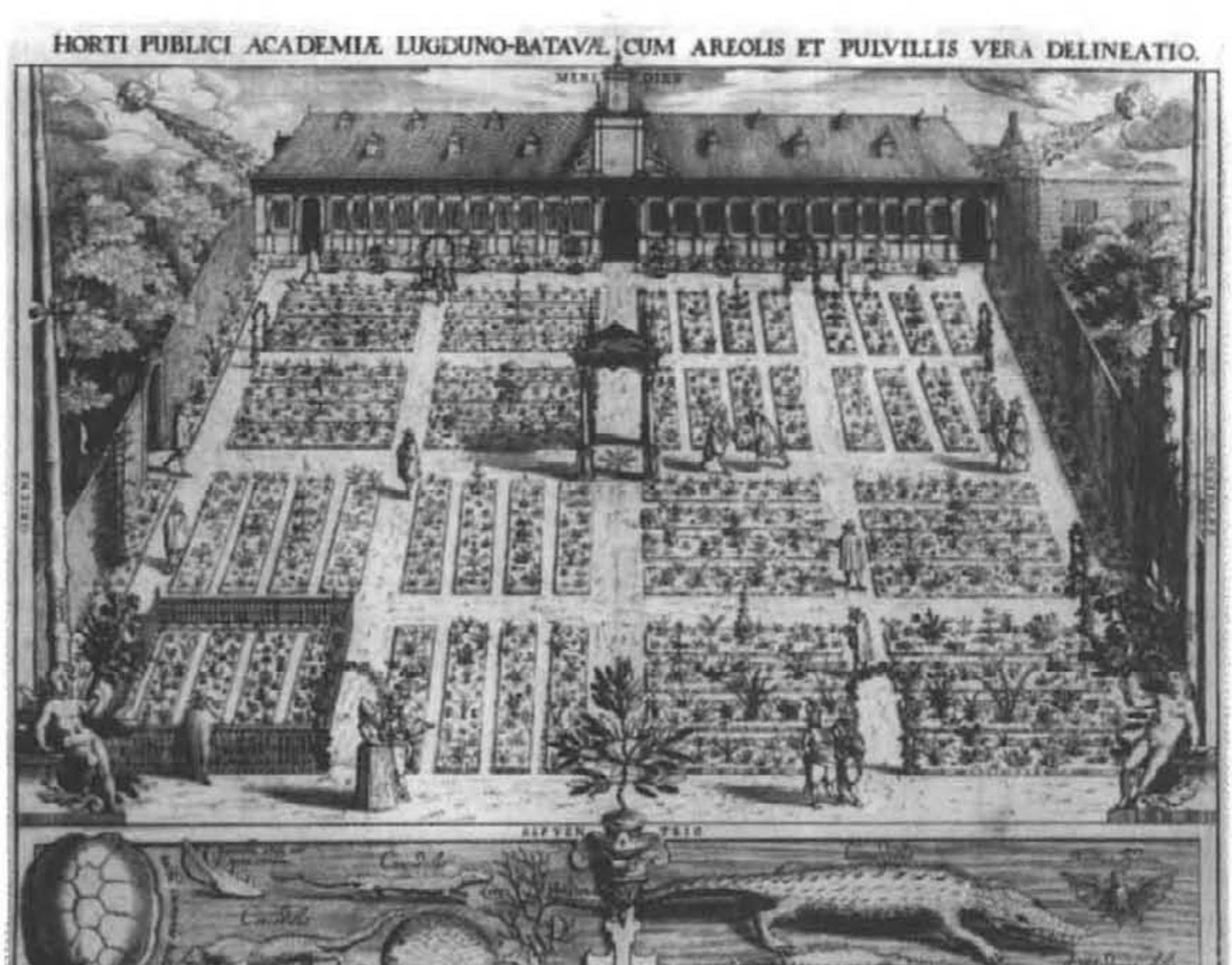

Figure 4.3 Willem Swanenburgh after I.C. Woudanus, *Leiden University Hortus Publicus*, engraving, 1610. Photo courtesy of Rijksmuseum-Stichting, Amsterdam.

compendium of wonders of the natural world Clusius compiled in Leiden and published there in 1605.[17] That de Gheyn would have had access to a specimen of the *Diodon hystrix* in Leiden seems clear; moreover, the status of this fish as an object of curiosity at the time is amply documented.[18] How de Gheyn views the blowfish and the modes of verbal and visual description he engages to describe it are what is crucial here.

De Gheyn scanned the surface of the prickly orb of fish before him, first from in front of it and in line with its line of sight and then, in the rendering at the right of the sheet, from its right side. Finally, he scanned it again in order to record, in the inscription below, the shifting colors of its body. The continuity between the abbreviated and spiky forms of the drawing and the forms of the text below is suggestive, and the pace with which he describes the alterations of color from the back to the belly and from the fins to the body (the text is entirely without punctuation) is consistent with the sustained pattern of lines defining the fish above. Significantly, the descriptive responsibilities of the verbal and the visual accounts de Gheyn provides are distinct: the drawing of the fish conveys the form, and the inscription the color. De Gheyn's written description does not reiterate what is made visible in the accompanying image; it supplements it. And by describing the colors of the fish in the colors of pigments (Cologne earth, umber white, iron black grayish, yellow ochreish light gray) de Gheyn describes the fish *as a picture*.

De Gheyn's drawing offers a verbal description that is functionally distinct from the visual description it provides. His verbal description is of a different order—the order of color, of a painter's colors. The inscription does not allude to an external frame of reference beyond the palette, and in this sense the description de Gheyn proposes is entirely self-referential: "This fish" to which de Gheyn refers in the opening line of the inscription is no longer the fish hanging in the Leiden gallery, or the fish returned to the Netherlands after long voyages, the component of a collection of *naturalia*, or this fish as compared to any similar or other fish. "This fish" is the fish of de Gheyn's drawing, the fish of a picture in the making.

Reconstituted according to de Gheyn's indications—colored in—such a picture would effectively convey the forms and colors of this exotic natural specimen. To a very significant extent these were the characteristics according to which distinctions of class and sort were made within contemporary natural history.[19] That this is so is borne out in Clusius's accounts of the natural world in general, and in his description of the *Diodon hystrix* in particular, which is directly relevant to assessing the status of de Gheyn's description. In his voluminous *Exoticorum*, Clusius documents the four fish he identifies as blowfish in the course of four separate chapters of book 6. Of the first three of the fish he describes, Clusius writes that he had observed them hanging in "museums" belonging to individuals in Amsterdam and in Montpellier.[20]